DISCOVERY

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DISCOVERY

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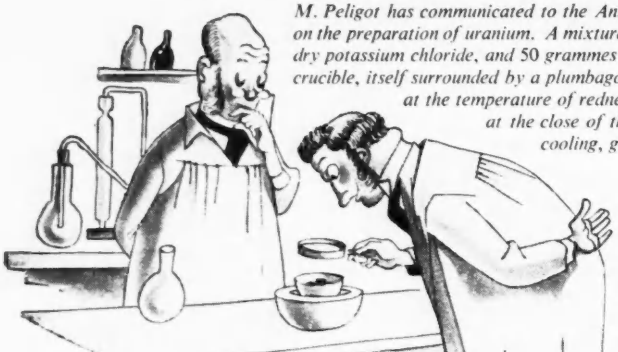
CONTENTS

OUR COVER: Our cover this month shows part of the French Greenland Expedition under its leader Paul Emile Victor. Use has been made of the Snocat, which is playing an important part also in the Antarctic expeditions during the IGY. Some of the recent French work is described in the IGY column, p. 438. (*Photograph by Expéditions Polaires Françaises.*)

M. Peligot finds uranium



M. Peligot has communicated to the Annales de Chimie et Physique (xvii, 363) a short note on the preparation of uranium. A mixture of 75 grammes of uranous chloride, 150 grammes of dry potassium chloride, and 50 grammes of sodium in fragments is introduced into a porcelain crucible, itself surrounded by a plumbago crucible. The reaction is effected in a wind furnace at the temperature of redness; but the heat must be increased for a short time at the close of the operation. In the black slag may be found, after cooling, globules of fused uranium.

The new method of producing uranium was announced in the first issue of Nature in 1869. Monsieur Peligot, who twenty-eight years before had first isolated the metal, discovered by Klaproth in 1789, was opening the door a little more widely to the possibility of an Atomic Age a century later.

In recent years the priority attaching to the atomic energy programme has restricted their availability, but uranium compounds are now again available and figure among the several thousand fine chemicals of very high purity supplied by B.D.H. for science and industry.

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THE PROGRESS OF SCIENCE

ENERGY IN UNDER-DEVELOPED COUNTRIES

National prosperity, as measured by the standard of living, is closely related to consumption of energy *per capita* no matter whether this be regarded as the cause or the effect. Thus, countries having ample energy resources have advanced through the use of these resources for industry while others, for example, Denmark, becoming prosperous through the development of agriculture or of other natural resources, have attained high utilisation of energy even though its production has had to be through imports of fuel or of electricity.

In their struggle to advance the welfare of their often large populations, with consequent studies of the methods by which this might be brought about, the under-developed countries are now clearly understanding the importance of mechanical power towards this end. In Great Britain and other industrialised countries where, in spite of our grumbles, we are "well fed and watered", there is a general lack of appreciation of the fact that many of the world's population are already under-nourished and that the present rate of increase of twenty to thirty millions a year is likely to make the position worse in the future. Obviously some action must be taken to ensure that serious food deficiencies—which are, quite understandably, a major cause of discontent and a danger to world peace—will be avoided. There are still large areas which are uncultivated, or inadequately cultivated, not through any basic infertility or adversity of climate, but mainly because of a lack of water and of mechanical power to assist man's efforts. More than half of the inhabitants of the earth are peasant farmers living at bare subsistence level and with little or nothing to spare to feed their fellow men. How can it be otherwise? A man's rating of working, equivalent to about 60 watts, may result in an annual output of some 100 kWh while his bullocks or other working animals can produce only six or eight times this energy, and even then at quite a high cost when their short working life and heavy maintenance are taken into account. The present consumption of all energy per head in the under-developed areas, as a group, is equivalent to about 1100 kWh as compared with 10,500 kWh in the group of more advanced countries. To take specific examples from the figures for electrical energy alone, that for Norway (the highest in the world) is 6800 kWh per head, and for Great Britain 1650 kWh, while for Ecuador it is only 48 kWh per head, for India 30 kWh, and for China under 10 kWh.

Especially in Great Britain, and in other countries where rapid progress has been made in the development of nuclear energy, there is a very strong tendency to regard such energy as the complete answer to all the problems of energy supply in the future. With all respect to its protagonists, this is not likely to prove true for a long time to come. It would be very rash to predict that nuclear power plant will never be universally employed for all purposes, but certainly its requirement of high capital investment will make transfer to this type of energy difficult for poor countries. Such countries are also sadly deficient in scientific and technical manpower. The obvious implications of almost complete dependence upon the more advanced countries, both for money and technicians, militate against its general use. Prof. P. M. S. Blackett made an eloquent plea for financial aid to underdeveloped countries in his presidential address to the B.A. at Dublin. (See DISCOVERY, 1957, p. 373.)

There are good reasons, therefore, why the under-developed countries are paying considerable attention to the possibilities of supplying their energy needs, especially in thinly populated areas, by other means.

Disregarding natural resources in the forms of hydro-power or the fossil fuels which, in under-developed countries, are often entirely lacking or are located too far away from areas where they are needed, what are the possible energy sources which have not yet been exploited on a significant scale? There are solar radiation (the possibilities of which are outlined by Dr Stead on p. 417), wind energy and, in some special localities, geothermal heat, tidal energy, or the potential energy corresponding to the large fall in the temperature of the sea between the surface and deep water.

In the advanced countries, research and development work on such energy sources has been in progress for some years, with a present prospect of technical and economic success.

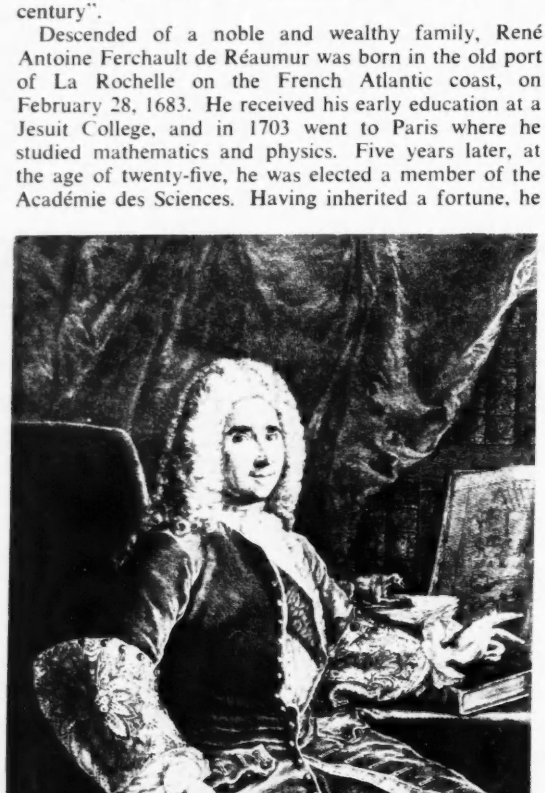
During the last three years several important conferences have brought the two groups together for discussions. The World Power Conference meeting in Rio de Janeiro in July 1954 had sessions on wind and solar energy. The UNESCO New Delhi conference, in November 1954 (*see* DISCOVERY, March 1955, p. 120), dealt solely with these two subjects. There was the World Symposium on Applied Solar Energy in Arizona in November 1955, and a conference on "Electricity in the Tropics" in Paris in May 1956. The sectional meeting of the World Power Conference in Belgrade this summer had the theme "Power as a Factor of Development of Under-developed Countries". Discussions of this kind have shown the limitations of nuclear power for countries without widespread electrical networks, and the United Nations Department of Economic and Social Affairs, New York, has just published a report, "New Sources of Energy and Economic Development". This deals comprehensively with the five local sources of energy already mentioned, and it seems fair to draw the conclusion that these sources might well be useful in solving the problem of energy supply for communities in thinly populated areas remote from electrical networks or from bulk supplies of fuel. Failing a cheap, and simply operated, nuclear power plant in the capacity range 10 to 100 kW (and there is no prospect of such plants becoming available in the near future), a combination of power production from the wind and sun, with perhaps waste organic matter used as a firm

source of energy to supplement these two random sources, could be used. Continuation of the present research efforts to evolve the necessary power plant, together with some experimental schemes to discover the technique of utilising random power to the best advantage without expensive storage, might go far towards solving the power problem for these areas, especially during the early stages of their development.

RENE DE REAUMUR (1683-1757)

The name of Réaumur, who died two hundred years ago on October 17, 1757, is remembered chiefly for the thermometric scale which he designed. This, however, was but one of a multiplicity of subjects that engaged the attention of this versatile scientist who has been described as "The Pliny of the eighteenth century".

Descended of a noble and wealthy family, René Antoine Ferchault de Réaumur was born in the old port of La Rochelle on the French Atlantic coast, on February 28, 1683. He received his early education at a Jesuit College, and in 1703 went to Paris where he studied mathematics and physics. Five years later, at the age of twenty-five, he was elected a member of the Académie des Sciences. Having inherited a fortune, he was able to lead the life of a private scholar, following up any line of research that interested him.



René Antoine Ferchault de Réaumur, from the line-engraving by P. Simmoneau after A. S. Belle. Impression in the collection of the Wellcome Historical Medical Museum. (*Published by kind permission of the Trustees.*)

Some of his most useful work was the outcome of investigations undertaken when in 1710 he was asked to supervise the preparation of an official description of French arts and manufactures. The method of tinning iron which he devised is still being used today; he also introduced an improved method of iron refining, and invented the porcelain known by his name, and a white opaque glass. His book on the chemical differences between iron and steel (1722) was translated into English and German. In recognition of his fundamental contributions to the development of iron and steel manufacture he was granted a pension of 12,000 livres, but he requested that the money be given to the Academy for the promotion of improvements in the industrial arts.

The greater part of his life Réaumur spent quietly on his estate at Saintong or in his country house at Bercy near Paris, but his researches took him to many places on a wide range of scientific pursuits: he made valuable reports on afforestation and investigated the gold-bearing rivers, the turquoise mines, and the fossil beds of France.

For his famous thermometer which continues to be used in some European countries for medical and domestic purposes, Réaumur employed a mixture of 4/5 alcohol and 1/5 water and called the freezing point zero and the boiling point 80°. He also studied the expansion of gases and fluids and specific heat.

An accurate and patient observer in the field of natural history, he demonstrated the ability of crustaceans to replace their lost limbs, established that the development of the shells of molluscs is due to a secretory process, attempted the artificial incubation of eggs, studied the formation of pearls in mussels, the locomotion of starfish, the electrical apparatus of the torpedo, the phenomenon of marine phosphorescence, the growth of algae, and the production of silk by spiders.

No better example of Réaumur's ingenuity could be cited than his method of investigating the process of digestion, performed in 1752. For this he made use of a pet kite which, according to the habit of its species, vomited after an interval anything that it could not stomach. He constructed metal tubes open at both ends, placed food inside them, and gave them to the kite to swallow. When they were ejected, the contained food was found to be softened and bitter to taste. Wishing to obtain samples of gastric juice, he put small sponges in the tubes, attached to a length of thread. The juice thus collected softened food *in vitro*, but did not completely digest it. (He had not performed the experiment at body temperature.)

Réaumur's handsomely produced and illustrated *Mémoires pour servir à l'histoire des insectes*, 1734–42 in six volumes—the seventh volume was left unfinished at his death—is one of the finest records of specialised research ever to be published. It discusses the effect of heat on the development of insects and their larvae and contains valuable observations on leaf-boring and gall-forming insects.

A foreign member of the Royal Society, Réaumur

died at La Bermondière, le Maine, on October 17, 1757. He bequeathed to the Académie des Sciences 138 portfolios of his manuscripts, and his natural history collections. A kindly and amiable man who went out of his way to help young naturalists, he possessed a flowing and animated style of writing. The great Cuvier said of his book on insects that it "can be read with all the interest of the most absorbing romance".

MONSTROUS CLUES TO THE NORMAL

Animal monstrosities, terata as they are technically called, used to be regarded as wonders of nature or alternatively as marvels of supernatural origin, and there are still people who will travel far to see a two-headed sheep or a legless foal. For biologists the study of monsters, or teratology, has a less morbid attraction. The real wonder is, of course, not that a small proportion of animals should be malformed but that so many should follow the fantastically complex path of development from egg to adult with success. Monsters can, however, provide some information about normal development in an indirect way.

For instance there have been those who supposed that the foetus, during intra-uterine life, fed through its mouth by swallowing the amniotic fluid in which it is bathed. If this were the whole truth it would follow that no foetus could survive and grow unless it had a functional gullet. In fact fully grown foetuses occasionally come to birth although they lack a gullet. They must have had some other way of feeding. This does not at all prove that normal foetuses do not feed through their mouths, it simply excludes the theory that they can feed in no other way.

Teratology, as a method of investigation of normal development, suffers not only from the rather tortuous kind of information it yields but also from the fact that the monster is an end-product of a disturbance of development whose actual nature is not known. It is therefore not surprising that developmental biologists have generally preferred to carry out their own experiments rather than wait for nature to perform one which may look interesting but is unnecessarily difficult to analyse.

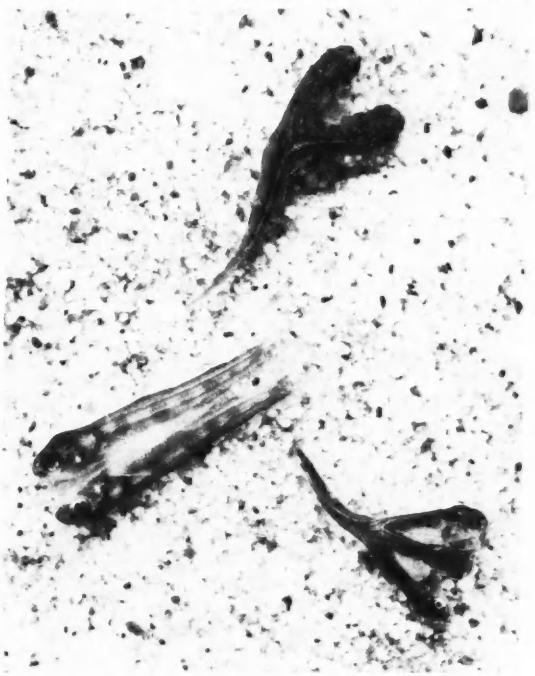
Teratology cannot be ignored, however, if only because of the so-called congenital malformations in man. Clinically the problem here may be to repair defective individuals where this is possible, but it is also important to find out where development went wrong in particular cases, and why, so that there is some chance of preventing similar malformations occurring in future generations.

Developmental biology recognises three main categories of abnormal development defined in terms of their ultimate causes. The distinction between them is useful, but has no absolute validity since a particular abnormality may fall into any two or all three simultaneously. The first is perhaps the simplest. If a developing system is subjected to a sufficiently severe insult it may be thrown off its stride. Mechanical, physical, chemical, or biological agents can be the offenders, and the consequences for the victim may be apparently unrelated to the cause. For instance a frog's egg held upside down for a short period after fertilisation, subjected, in other words, to a reversal of the gravitational field, may give rise to a double-headed monster.

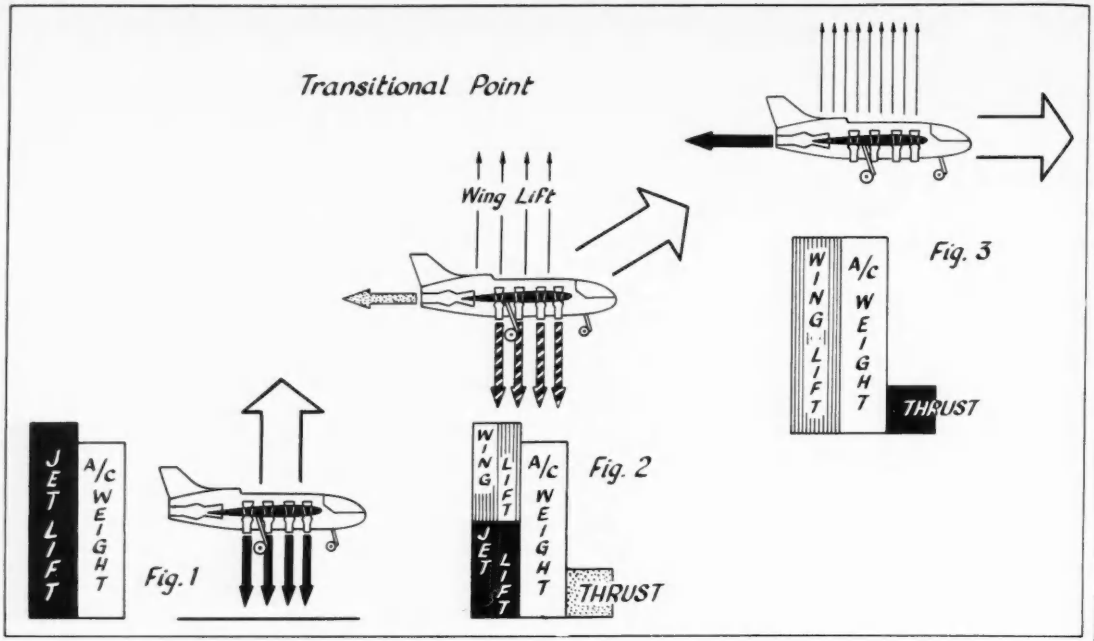
The second category is less easy to define. It includes all those aberrations of development that are not the product of environmental interference but are innate in the egg at fertilisation though not heritable through many generations. It is probable that the three-headed and double-headed trout embryos so beautifully shown in the accompanying photograph are of this kind.

Finally, there is the immense category of abnormalities that owe their origin to the constitution of the nucleus of the fertilised egg. These are the genetic abnormalities which result from mutation and recombination in the chromosomes of the cells which give rise to egg and spermatozoon. Not all the effects of mutation can fairly be called abnormal in the pathologist's sense of the word. Some have very slight effects and may even lead to the organism developing in an unusually advantageous way. Many, however, do produce monsters.

Evolutionists have, in recent years, concentrated most on the study of genetic mutations and allied phenomena. This is because they may provide useful material for natural selection to work upon as chromosomes which have suffered mutation can be "passed on" through many generations. However, the extremely interesting and important work of Prof. C. H. Waddington (see, for example, *Evolution*, vol. 10, 1956) has shown that changes in development caused by environmental insult, if repeated in successive generations, may also have



Assorted trout mutations one month old: Siamese; 2-headed; and 3-headed. (*Photo W. T. Davidson.*)



The method of take-off and transition to normal forward flight is illustrated here for an aeroplane of orthodox configuration, and which is fitted with jet-lifting engines. In Fig. 1 the downward-pointing jet engines are run until their combined power exceeds the total weight of the aircraft, whereupon they lift the machine straight into the air. The relation of thrust to weight is shown in the drawing at the side. In Fig. 2 the forward propulsive turbojet, which is mounted at the rear of the fuselage (like, say, the Short SC-1), is brought into operation for forward flight. At this point of transition between vertical and horizontal flight, the lifting power of the wing starts to become effective, and as increasing dependence can be placed upon it, the power of the jet-lift engines will be reduced accordingly, and a flight pattern like that shown by the arrows will result. The relation of jet-lift to weight and wing-lift to weight is again shown, and also the part played by propulsive thrust. When forward flight is possible after transition (Fig. 3) the jet-lift engines will be closed down completely and the aeroplane will fly in a normal way. In level flight, the lift of the wing will be equal to the aircraft's weight, but wing-lift alone can only be generated by forward movement, which is imparted by the thrust of the rear jet engine. On aircraft of the Ryan Vertijet type, with a single high-power turbojet, and which take off in a vertical attitude, transition is accomplished by increasing the thrust of the jet engine during conversion to forward flight until the wing controls become effective, and the aeroplane can fly normally.

evolutionary consequences. His findings cannot be fairly treated with brevity, but they form another link in the chains that bind together the studies of normal and abnormal development.

VERTICAL FLYING

Countries on both sides of the Atlantic have lately been showing intense interest in vertical flight. Not since the early days of the helicopter has so much effort, money, and time been spent on the vertical flying machine. Today, however, vertical flight is being furthered not by rotor blades or wings of any sort, but by jet-lift, an aeronautical development that has captured the interest of aviation engineers

Jet-lift, as its name implies, is a method for getting aeroplanes into the air by the thrust of turbojet engines alone. These engines, mounted singly, in pairs, or in clusters according to the ideas of designers, give a power output greater than the total weight of the aeroplane, and providing the thrust of the engine or engines is maintained at a given output the craft can be kept rising or hovering under perfect control.

For years aircraft designers have striven to find an answer to the problem of ever-lengthening take-off runs made necessary by increasing aeroplane weight. They have introduced numerous high-lift devices, and have used such aids as rockets to boost the aeroplanes into the sky and shorten the take-off. These measures have been largely palliative, however, and most aircraft designers have been ready to admit that the vertical take-off aeroplane was a more attractive proposition.

Numerous experiments were conducted with powerful propeller-turning aircraft, among the most recent being the Convair "Pogo" and the Lockheed "Salmon", both of which used turboprop engines to lift the aircraft into the sky. These machines were successful in their way, but still left much to be desired. The high thrust-to-weight ratio of the turbojet offered the most promising solution, and when the characteristics of these engines were fully understood and their potential appreciated, work was begun, both in this country and the United States, to applying them to an aircraft designed specifically for vertical flight.

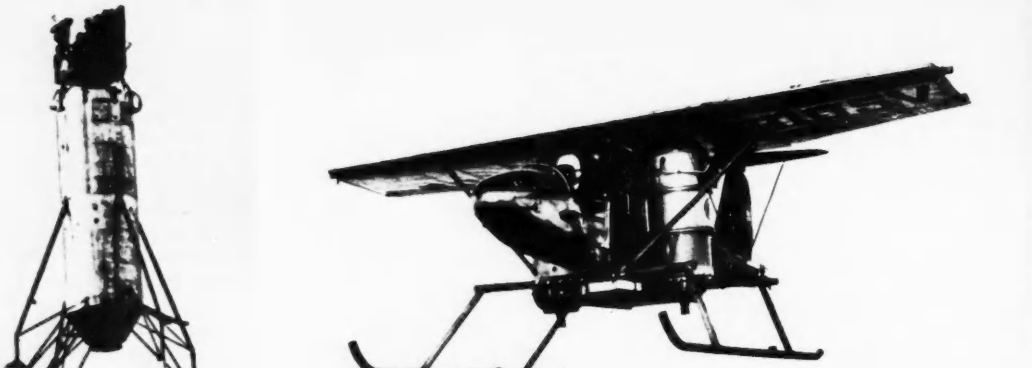
After considerable research and experiment, a successful vertical take-off machine was produced by the Rolls-Royce company in England in the form of the Thrust Measuring Rig, more popularly known as the "Flying Bedstead", and this machine first flew in August 1954. The Bedstead consisted essentially of a framework containing two Rolls-Royce Nene turbojet engines, an arrangement for the pilot, and his instruments and controls. A unique feature of the machine, however, was the Farnborough-developed auto-stabilising system, which used compressed-air bled from the engines to effect control over pitch and roll and permit forward movement. This same system was later to be used on the Short SC-1 machine, which first made its appearance in December of last year.

The Flying Bedstead was followed by the Bell VTOL (Vertical Take-off and Landing) aeroplane, developed in the United States; and this machine—a simple construction job employing a glider fuselage—was equipped with two low-thrust turbojets which provided power for take-off and which tilted for forward flight. A further jet engine supplied air for wing-tip and tail jets for low-speed control.

As interest grew, France entered the picture with a machine designed by Count Helmut von Zborowski, called the Coleopter because it had an annular wing, which was designed to provide lift for forward flight. Several successful flights were made with a model of this machine, and then the French aviation organisation SNECMA took up its development. This work progressed to the construction of a framework embodying a full-scale Atar turbojet, which could be flown under control in a test gantry. Subsequently, this device was to be improved and fitted with a pilot's seat for free flight.

Development went ahead by the Bell company in America, also the Ryan concern, who concentrated their attentions on a delta-winged aeroplane powered by a single Rolls-Royce Avon turbojet, which took off vertically and converted to a normal horizontal flight attitude when a satisfactory height was reached. This aeroplane, known as the X-13 Vertijet, has proved its

The Rolls-Royce Thrust Measuring rig, or Flying Bedstead, the first successful machine to use turbojet engines for vertical flight. The two Nene engines discharge exhaust gases through outlets beneath the machine, and the Bedstead is balanced by forcing compressed air through the jets on all sides. The total thrust of each engine is about 5000 lb.



Left. The SNECMA Atar Volant P-2, which consists of an Atar turbojet fitted with directional controls, wheels, and a pilot's seat on the top. For vertical and forward flight the engine is used and the jet deflected, while control about the vertical axis is maintained by compressed air jets mounted on opposite sides. The pilot has an ejection seat and an escape pod. The Volant is the second machine in a development programme proposing five VTO aircraft. *Right.* The Bell VTOL aeroplane, which achieved vertical flight by two 1000-lb. thrust Fairchild J-44 turbojets, and which tilted to provide thrust for propulsive flight. A third jet, a Turboméca Palouste, mounted behind the pilot, supplied compressed air to wing-tip and tail control jets.

ability as a vertical take-off machine by flying straight up to a height of 10,000 feet from a standing start. Numerous conversions to horizontal flight have already been made, and for this purpose the pilot is equipped with a tilting seat.

British work in the VTO field has been represented during the past year by the Short SC-1, which is a step forward from the Flying Bedstead in that the pilot is provided with an enclosed cockpit, there are five engines of low thrust to power the machine, and—most important of all—the aircraft is able to fly in a normal way without changing attitude after a vertical take-off has been made. This is precisely what designers are striving to achieve for ultimate application to large aeroplanes able to carry a payload. When the SC-1 has proved itself, there is no doubt that the knowledge and experience gained will be put towards a yet further improved aeroplane.

It is difficult to say which country is ahead in work on jet-lift, for each has its own approach to the problem and the requirements differ, but some idea of British eminence in the field can be gained from the fact that a Rolls-Royce engine is used in the Vertijet, and two Armstrong Siddeley Viper turbojets are employed on the latest American VTO aircraft—the Bell X-14, which made its appearance only on June 27. The Short SC-1, which has yet to make a transitional flight, would appear to be the most practical VTO machine yet, for it can make normal level take-offs from runways if desired (and has done so), and unlike the Ryan Vertijet, the pilot's seat is not required to tilt, for after a vertical take-off on the power of four of the five RB-108 jet engines, he merely switches over to the fifth jet, which provides propulsive thrust.

French ideas on the matter have reached a stage where a second Atar-powered machine, the P-2 Volant, has flown successfully under full control by a pilot. This awesome device was seen by visitors to the Paris Salon at Le Bourget in May, when it was demonstrated that a turbojet mounted on end could be made to fly, for this is essentially what the Volant is; a jet engine with a pilot seated on the top. Directional control is achieved by deflecting the jet, while control about the vertical axis is maintained by two pairs of opposite-mounted compressed air jets.

As has been explained, the essence of flight by jet-lift is the use of jet engines with a thrust exceeding the weight of the aircraft. The margin must be fairly substantial—about 20%—and the thrust should have a fairly flexible range in order to keep the machine under control during such difficult periods of flight as transition, and during a landing.

With such resources, the pilot of the future may be able to carry loads from city-centre to city-centre with considerably more efficiency than the helicopter has so far been able to do. While still in its early stages, jet-lift has proved a sound and promising means of conducting vertical flight, and may well set the pattern for the future.

RESEARCH AT WESTINGHOUSE

Westinghouse Electric Corporation's new Research Laboratories are situated on a 72-acre site near Pittsburgh, Pa., U.S.A. Eleven departments, including physics,

chemistry, electromechanics, electronics, insulation, and nuclear physics, have already moved into the building, where space has become too small and a three-story L-shaped building is being added.

Work has been progressing on a new light source, based on light emission by phosphor powders embedded in an insulator and subjected to the action of an alternating electric field. Sandwich-like glass panels, $\frac{1}{8}$ inch thick and 1 foot square, are coated with a transparent but electrically conducting film. Over this is spread a thin layer of polyvinyl chloride plastic, in which is embedded a zinc sulphide-type phosphor, on top of which is an aluminium conducting coating. The panel thus resembles a capacitor, with two conducting layers separated by a dielectric.

When electricity is applied (350-volt, 300-cycle a.c.), the brightness of the panels is 100 foot-lamberts, and efficiency is 3 lumens per watt. The power source is a 25-volt d.c. battery. A transistor circuit converts the d.c. to 350-volt, 8500-cycle a.c. Due to the fact that some phosphors have more than one emission band, frequency can affect the colour emitted. The phosphor is green when the power is below a frequency of 1000 cycles. Above 5000 cycles, the light emitted is blue. In between are various shades of blue-green. The colour white is obtained by mixing red, blue, and green phosphors. The brightness of electroluminescence is proportional to both the frequency and voltage of the electricity applied. Raising either one increases the brightness. Thus 2000 foot-lamberts was obtained by using a 600-volt, 20,000-cycle a.c. power source. Raising the voltage further causes dielectric breakdown.

Peak efficiency of 9 lumens/watt was achieved by using electricity of only a few hundred cycles and a few hundred volts. Applying higher or lower values only decreased the efficiency.

A new type of television camera tube, called the "Ebicon" (Fig. 3), is also being developed. The name comes from the initials of the phrase "electron bombardment induced conductivity" which is the phenomenon basic to its operation. The device consists of a layer of selenium, which, when properly prepared, is quite a satisfactory insulator. A scanning beam of electrons from a gun in the rear of the tube charges the surface of the layer uniformly to a potential at which no further electrons from the beam can land on the layer of selenium. In this condition, no signal is received on the lead connected to the opposite side of the selenium layer. If an electron from the photosurface on which the light image is projected is accelerated and driven into the selenium with high energy, it can produce an avalanche of conducting electrons, which flow only momentarily and discharge the back surface of the selenium. When the scanning beam returns to this spot, it will recharge the selenium, and a current will flow in the signal lead. This current is amplified by ordinary vacuum tube amplifiers and used as a video signal for the transmission of television images. The important

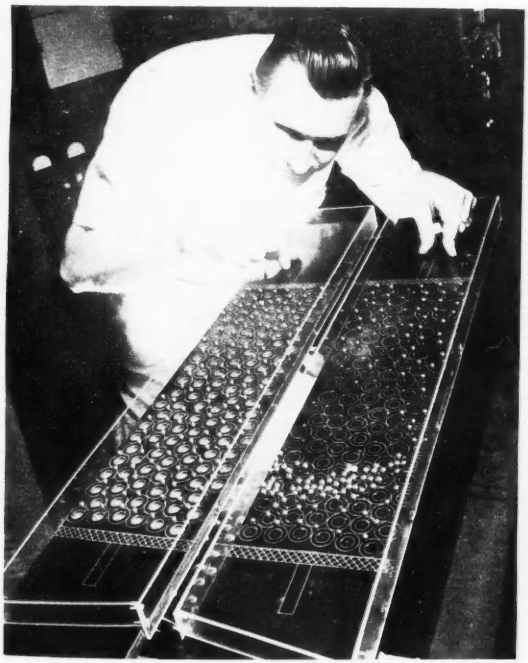


FIG. 1. Demonstration using steel balls to simulate electrons to show how sulphur hexafluoride gas quenches an electric arc.

FIG. 2. Test showing quenching of electric arc by gas injection of sulphur hexafluoride.

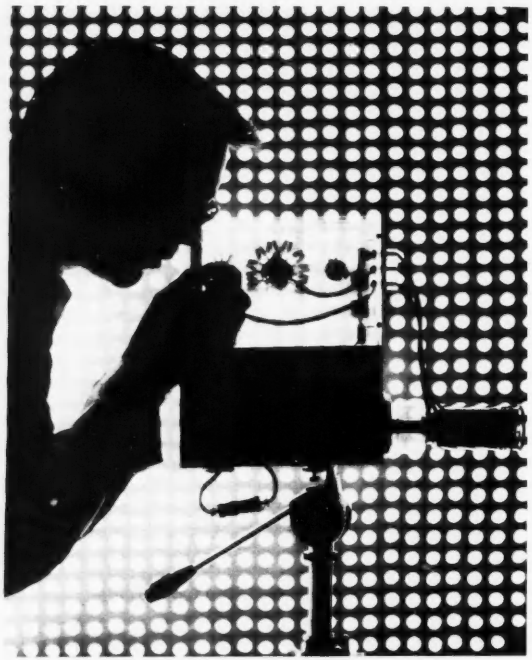


FIG. 3. New "Ebicon" television camera tube. It can "see in the dark", and operates on electron multiplication.

feature of this device is that for each high-energy electron entering the selenium layer, 100 or more conduction electrons will flow. In this way, a gain is achieved which overrides the noise inherent in the subsequent vacuum-tube amplifiers.

Research now in progress on the phenomenon of bombardment-induced conductivity suggests that great improvements can be made and that eventually a camera pick-up tube may be capable of recording as a distinct flash every photoelectron leaving the surface. Such sensitivity will open up many fascinating possibilities for scientific and practical application.

A new technique for arc-quenching is being developed. It employs a gas literally to "soak up" the arc's electrons, in much the same manner as a sponge soaks up water. It is hoped that the "electron sponge" process can be used to make better circuit breakers (Fig. 1).

The study of the breakdown of electric arcs in gases is one of the oldest fields of research since the discovery of electricity. One phenomenon about which very little is known, however, and which offers great promise in quenching electric arcs, is the rôle played by certain types of gases which can capture electrons. Because of this property these gases can be used to quench arcs by virtually immobilising the electrons.

One gas under investigation at the Laboratories is sulphur hexafluoride, SF_6. Like the other electronegative gases in this category its molecules will attach themselves to an electron, thus becoming negatively charged. The ability of SF_6 to extinguish an arc was demonstrated by injecting some of it into a tube through which a 10,000-volt arc was passed. Before the introduction of the gas, air in the tube permitted the arc to jump from one electrode to the other (Fig. 2).

Modern aircraft and guided missiles are using a great amount of electrical insulating materials; however the rapidly increasing temperatures encountered inside aircraft during supersonic flight have brought the demand for something better.

A new, high-temperature, high-voltage insulating material developed jointly by Westinghouse Electric Corporation and Dow Corning Corporation may prove to be efficient in tomorrow's aircraft. The new insulation is a solventless silicone resin, which can be formed into thick sections of solid, heat-resistant insulation for use in complex electrical equipment. Research scientists say that, by eliminating the solvent formerly necessary in other heat-resistant resins, it is possible to produce an insulation which is entirely free from air spaces, or bubbles. With previously available high-temperature silicone resins, a solvent was necessary to make the resin fluid enough for application, but then the solvent often caused bubbles to form as the insulation hardened into solid form. By developing a solventless material this problem has been eliminated.

Air spaces in insulating materials are weak spots which will break down at high voltage, thus causing serious deterioration of the insulation.

In a demonstration a small transformer impregnated with a solvent containing varnish showed deterioration of the insulation where a high voltage was applied. An equal voltage was then connected across a similar transformer impregnated with a solventless silicone resin. As the voltage was applied to the first transformer, electrical discharges occurred because of air spaces within the material. No such discharge occurred when voltage was applied to the silicone transformer. It is claimed that the newly developed silicone insulation provides greater heat resistance than that obtainable in any other insulating resins, with similar filling characteristics, and is another step towards operating electrical equipment at higher output capacity or in higher ambient temperatures. It is hoped that because of its outstanding heat resistance, solventless silicone insulation can be used to protect electronic components in aircraft and guided missiles and it also shows great promise for use in generators and motors. Because of its ability to operate continuously at 250°C for thousands of hours and because it is bubble-free, solventless silicone insulation extends the horizon of electrical insulating materials.

BY YON BONNIE BANKS

The academic study of zoology has widened greatly in this century. It began with interest restricted to consideration from the evolutionary standpoint of problems of form and development. After the First World War it expanded to include comparative physiology and experimental embryology while the study of ecology, the

Loch Lomond, a plate from the book by Harry D. Slack. (*Published here by kind permission of Blackie and Son Limited and the University of Glasgow.*)

organisation of communities in nature, extended from botany to zoology. After 1945 interest broadened again to cover the practical implications of ecology in conservation and the analysis of the behaviour of animals in the natural environments.

In keeping with this increased interest in what had been known as natural history, the universities have been taking—or where this was impossible sending—their students to study animals in Nature and many field stations have been established to meet this need. The University of Glasgow, near the largest lake in Great Britain, has not unnaturally paid particular attention to the study of freshwaters and in 1946 established a field station near Luss on the west bank of Loch Lomond. This consists of two large wooden huts, one for the study of freshwater biology, the other for work on insects, initially on biting midges, on a site made available by the late Sir Iain Colquhoun, Bart, of Luss. A motor launch fitted for limnological work and smaller boats complete the equipment.

The volume* now produced by the University gives a general account of the Loch and descriptions of its planktonic, free-swimming, and bottom-living populations, showing what has been achieved largely under the direction of Dr H. D. Slack, Senior Lecturer in Freshwater Biology in the Department of Zoology, during the first ten years of work. The Loch has major advantages as a site for research. Apart from its size, it consists of two very dissimilar regions. At the north it is a narrow and deep glacial trough forming a typical highland loch of low productivity, at the south it stretches out widely and is shallow with much emergent vegetation and higher productivity. While surface temperatures are very similar throughout and the plankton varies in quantity but not in quality, bottom temperature is consistently low in the deep northern basin but ranges widely throughout the year in the shallow southern region. This and the nature of the bottom deposits, revealed with almost diagrammatic clarity by the often multiple echoes received by the echometer, affect greatly the character of the bottom fauna.

By annual student collecting and by the more specialised activities of members of the departmental staff and of research workers, the invertebrates of the Loch—flatworms and annelid worms, crustacea and many kinds of insects both larval and adult, water mites and molluscs, both snails and bivalves—are being collected and identified and their distribution mapped. Apart from differences between highland and lowland regions of the Loch, there are changes in distribution with depth where five zones are recognised, (*a*) Flood Zone; (*b*) Littorella Zone, characterised by the lakewort, *Littorella*; (*c*) Isoëtes Zone, where this and other water plants grow in finer sediments than the sand found in the upper zone; (*d*) Sub-Littoral Zone, beyond the outer limits of rooted plants; and (*e*) Profundal Zone.

The most detailed faunal studies made to date concern the population of an offshore bank which raises the problem of maintenance by continual recolonisation. The suggestion is made that the early-hatched larvae of certain insects spend temporary life in the plankton and are carried passively to settle on submarine surfaces and possibly swimming upwards and being carried farther should these not prove suitable. Dr W. Russell Hunter writes with authority on the distribution of snails, in Loch Lomond in particular, but also throughout Scotland generally. He notes how impermanent in historical

* "Studies on Loch Lomond, Vol. I", by Harry D. Slack and others. Published for the University of Glasgow by Blackie and Son Limited, 133 pp., 15s. net.

and even more in geological terms are even the major lakes (it is estimated that the Lake of Geneva will have filled up with sediment in some 60,000 years at most) and how small are the possibilities of far-reaching evolutionary change under such conditions. Freshwater snails come from two sources; some are gilled snails descended from marine ancestors; the majority are lunged snails coming from the land. The latter display fascinating variations in respiratory mechanisms, some developing secondary gills, others retaining air in the lung, but only when occasional access to the surface is possible and never in early life.

The fish population varies with the nature of the Loch. In the highland end trout flourish, in the shallow southern water there are roach (here at the northern end of their range), fishes characteristic respectively of waters of low and high productivity. More widely ranging although commonest in the south are the less restricted pike and perch. Here are fascinating problems in the nature of the factors controlling distribution but Loch Lomond also has a fish all of its own, to be precise one that it shares with Loch Eck some thirty miles to the west. This is the powan or freshwater herring, *Coregonus clupeoides*, one of the several species of whitefish found scattered throughout the British Isles and elsewhere in northern Europe.

Special study is being made of this fish, which is very abundant. It feeds usually, but not always, on planktonic crustaceans. As befits a relic of the Ice Age, it spawns when temperatures approach 6°C, usually in January, and the eggs develop slowly in the cold waters, taking up to seventy days to hatch. Spawning occurs on banks of gravel or stone, where the eggs are scattered at random. Only slightly adhesive, they must settle largely in crevices and among plants. The developing eggs are devoured in vast numbers by the larvae of caddis flies and by the adult powan themselves.

Much must be omitted from this brief report, notably the work on biting midges which has been described in a series of scientific papers. But one may note the discovery by Mr J. A. Downes of the manner in which swarms are maintained and the further demonstration by Dr J. W. H. Lawson that in the dancing midges (Chironomids) the male swarms react to sound—best by a note approximating to A below middle C sung by the experimenter or, less effectively, by the purer note generated by a beat-frequency oscillator. In Nature this sound would appear to be caused by the female in flight and to be picked up by the large "bottle-brush" antennae characteristic of the male.

Enough has probably been mentioned to indicate the wide range of work being carried on at Loch Lomond and how suitable for university study are the environments and life found within and around freshwaters.

ARTS AND SCIENCE

In this day and age no one can be considered fully educated who does not know what science is about. For this reason, if for no other, the announcement that the University of Cambridge is to consider instituting a new Arts and Science Tripos is extremely welcome. If, as a result, Cambridge turns out a stream of graduates who combine with the customary skills of the Arts graduate the experimental outlook of the Scientist, then Great Britain will be better equipped to face the future than she has been to grapple with the present and the recent past.

Classical studies are said to be an unsurpassed means of teaching the student to think clearly; and the scientist, who has the saying of the great Hunter—"Why think? Why not try the experiment?"—to guide him, need not grudge the classics their reputation. He can rejoice to feel that, in the future, when the new Tripos yields its fruit, there will be more administrators who will understand science.

Cambridge University faces a formidable task if it undertakes to teach the essence of science to students who can give only a year of their time to the subject. Science is research, not knowledge; it is finding out, not learning. Science came into being when, in the 17th century, men like Galileo and William Harvey left the elegant gardens of logical argument for the vulgar workshops of "suck-it-and-see". Perhaps a course in the history of the philosophy of science would help, perhaps laboratory work, or perhaps even some small piece of research; but unless the new course brings home to its students that science is an experimental method of arriving at an understanding and a description of the world, and that when it arrives it is a working model and not an absolute, it will have failed. Whatever may be the value of its Arts ingredient, the other ingredient will not be Science.

It would be ungenerous to dwell on the difficulties and dangers of the proposal, though we must recognise that they exist. Much better to welcome it as a recognition that what the world wants is not scientists turned administrators, or politicians or what-have-you, but highly educated men in all walks of life who understand and can use science fruitfully. We therefore congratulate Cambridge General Board on its courage and good sense and hope that the new Tripos will be instituted and will have a long and honourable career.

ANIMAL SOUNDS ON TAPE

Animal sounds, from the roaring of lions to the chirping of crickets, are to be kept "on record" in a world collection to be housed in the Library of Natural Science at Cornell University in the United States. The collection will be maintained by the International Committee on Biological Acoustics, a body created last year by scientists from various countries meeting to discuss the problem at Pennsylvania State University.

The tape recorder has provided a new tool with which biologists may investigate the way in which birds, animals, insects, and even fish communicate by sound. The volume of recordings, however, is rapidly becoming unmanageable, and much of it is stored in laboratories not easily accessible to researchers.

The proposed "library" will provide an international repository containing a wide selection of animal sounds from all parts of the world. In addition, the Committee, is to publish an Annual Indexed Bibliography to inform biologists of material available.

RECENT DEVELOPMENTS IN SOLAR ENERGY APPLICATIONS

WILLIAM H. STEAD, M.A., Ph.D.

Washington, D.C.

Twenty years ago nuclear energy was the concern only of mathematicians and physicists in their laboratories, and interest in solar energy was limited to a few research laboratories and a few scattered applications of solar heat energy to experimental devices and installations.

By 1947 the spectacular success of the atomic bomb, combined with the enormous war-time drain on oil, gas, and electric energy supplies, had focused attention on the possible peace-time uses of nuclear energy. Within the last ten years increasing attention has been given to the development of these peace-time uses of nuclear energy which are of tremendous future significance to all industrialised nations.

The utilisation of nuclear energy is likely to come much slower in the underdeveloped areas of the world, however, due to its requirements for rather heavy capital investment and extensive scientific and technical resources, factors which can only expand slowly in such countries. These technologically backward nations, most of them located in the "solar belt",* might well take a good look at solar energy potentials before concentrating all their scientific and financial resources on atomic energy development.

IS SOLAR ENERGY READY?

What are the reasons for thinking that solar energy, long known and studied but little used, will be ready for practical application in the near future? They are well summarised in the Proceedings of two conferences, [1, 2] attended by thirty-six countries besides the U.S.A.

The exhibits of solar energy devices, ranging from small solar cookers, pumps and batteries to solar furnaces, engines, house heating and cooling devices, and stills for converting salt water to fresh water, were visited by 30,000 people. Of great interest was the number of scientific and technical papers reflecting successful experimental work on various applications of solar energy in the nations in what we have called the solar belt.

Similar, though smaller, international scientific conferences on solar energy have been held in Madison, Wisconsin,[3] and in New Delhi,[4] and a symposium on solar furnaces was held in Phoenix, Arizona.*

The Association for Applied Solar Energy has a world-wide membership of solar energy scientists and engineers and publishes a journal[5] in which two useful regular feature sections are included, one on World Research Activities, and one on Solar Abstracts. It also publishes a quarterly newsletter.[6]

There are now over 140 solar research and development centres in existence. Of these, 75 are in the U.S.A., 2 are in Canada, 6 in England, 12 in Europe, and 45 in the solar belt countries in South America, Africa, the Near East, Southern Asia, and Australasia. Some 42 of these centres (including 25 in the U.S.A., 1 in Canada, 2 in England, 4 in Europe, and 10 in solar belt countries) are known to be on a substantial continuing scale, with the other 100 representing individuals or groups of scientists engaged in some particular phase of solar energy research either in universities, private research enterprises, or in industry.

The status of solar energy research and its possible application can be very briefly summarised under five headings: the measurement of solar energy availability, and four potential uses of solar energy; use of solar heat energy (photo-thermal); conversion of solar energy into electricity (photo-electric); chemical uses of solar energy (photo-chemical); and improved biological uses of solar energy (photosynthesis, properly a division of photo-chemical).[7]

BASIC SOLAR ENERGY RESEARCH

Many of the university and government research centres cited above are concentrating on the basic research problems involved in trying to measure solar radiation at various locations and under varying atmospheric conditions. Thus some fifteen of the ninety-six scientific papers at the Tucson conference described work in this essential area.

During the International Geophysical Year much progress in understanding solar phenomena may be expected, with a resulting spur to solar energy research and development. Many of these developments in understanding solar radiation phenomena are discussed in DISCOVERY's monthly notes on the IGY.

Applied research dealing with the four potential uses of solar energy is emphasised by some of the university and government research units and particularly by the private and industrial research centres. We are here concerned primarily with the status of this applied

* The "solar belt", which extends beyond the tropics to approximately the 40th latitudes North and South, comprises the vast area of the Earth's surface within which utilisation of solar energy will be most effective, although temperate zone and even Arctic uses are technically if not yet economically feasible. While this solar belt excludes almost all of Europe and the U.S.S.R., as well as the bulk of North America and all of the Arctic and Antarctic lands, it does include all of Africa, the Near East, the southern half of Asia (including well over half of China and Japan), Australia, and the South Pacific islands, the southern part of the United States, Central America, the West Indies, and all of South America but the southern tip.

* Held on January 21 and 22, 1957, sponsored by the Association for Applied Solar Energy, Stanford Research Institute, Arizona State College, and the University of Arizona.

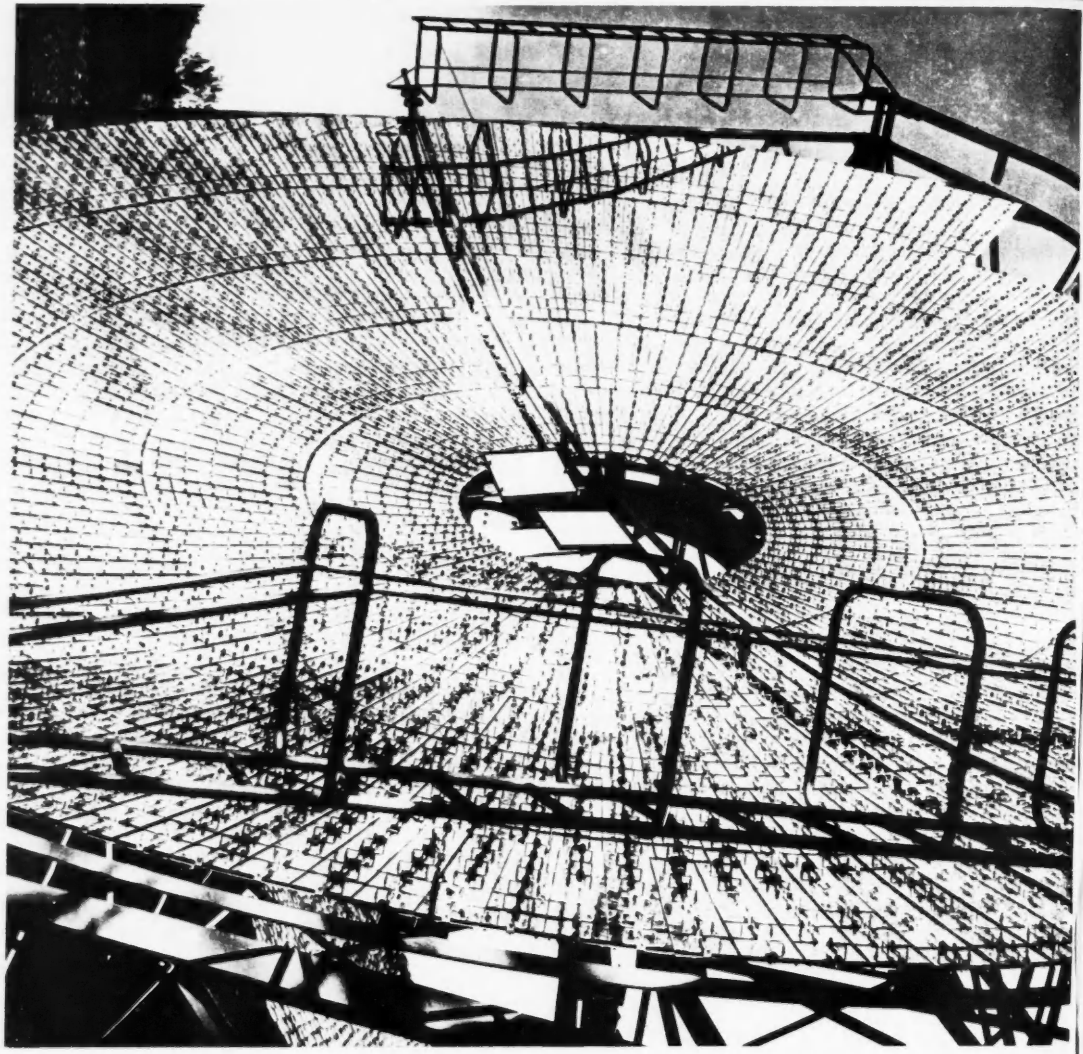


FIG. 1. Detail of Trombe's Concentrating Collector at Mont Louis, showing bending of flat glass plates to form curved surfaces.
(*All the photographs illustrating this article, except Fig. 7, are by courtesy of the Association for Applied Solar Energy.*)

research and development, while recognising that the rate of progress will be determined by success in the basic research activities now being pushed in the university centres.

PHOTO-THERMAL DEVICES

The effort to utilise solar heat energy (photo-thermal) has received most attention, although the other uses of solar energy (photo-electric and photo-chemical, including photosynthesis) may have the greatest potential value. There are three types of direct uses of solar heat energy: First, at ultra-high temperatures, between 1000° and 3500°C, secured through special parabolic concentrators or lens-focusing collectors, solar heat operates industrial furnaces requiring clean heat at extremely high temperatures for research and scientific purposes. Secondly, at temperatures up to 1000°C, secured by concentrating collectors, heat is transmitted to steam-generators, cookers, and low-temperature furnaces. Finally, low-temperature conversion processes (with flat plate collectors) are used for operating some solar pumps and engines, for water-heaters, for house heating, house cooling, refrigeration, and for solar stills to convert saline to fresh water.

SOLAR FURNACES

High-temperature industrial solar furnaces have been constructed and are being effectively used in Jena, Ger-

many (1921), at Mount Wilson, California (lens-focusing type built by California Tech. in 1932 and used in high-temperature metallurgy), at Kansas City, Missouri (built by Conn, of Rockhurst College, 1947), and at Paris (1946) and Mont Louis, France (1949), built by Felix Trombe. Trombe's furnace at Mont Louis is a parabolic concentrating type, the largest built to date, and is highly successful in work on oxides (Fig. 1). There have been a number of solar furnace installations in recent years, including those at San Diego, California (built by Convair Division of General Dynamics Corporation), at Fordham University in New York, at Nela Park in Cleveland (General Electric), at the Massachusetts Institute of Technology in Boston, at Moscow, U.S.S.R. (Energy Institute of U.S.S.R. Academy of Sciences), at New Delhi, India (National Physical Laboratories of India), and at Nagoya, Japan (Government Industrial Research Institute); and the Government of Algeria has built two at Couchet and Bouzaresh, the latter the second largest in the world, used for direct fixation of nitrogen in the atmosphere to produce fertiliser.

The U.S. Air Force is undertaking to build a solar furnace in New Mexico which will achieve temperatures of 7000° to 8000°F to test the heat-withstanding capacities of materials and weapon components.[5]

SOLAR COOKERS

In the middle temperature ranges perhaps the solar cooker is the best illustration of a practical application of solar heat. The simplicity of the solar cooker is its great virtue (Fig. 2). Dr Maria Telkes, of New York University, has also used four flat surfaces or mirrors to direct the sun's rays into oven models that achieve temperatures of from 350° to 470°F.

FIG. 2. Mrs Martha Tarcici fries eggs on a solar stove designed by her husband, Adñañ Tarcici, Beirut, Lebanon. The stove can be folded and packed for picnics or a day at the beach. The cost is about £5.

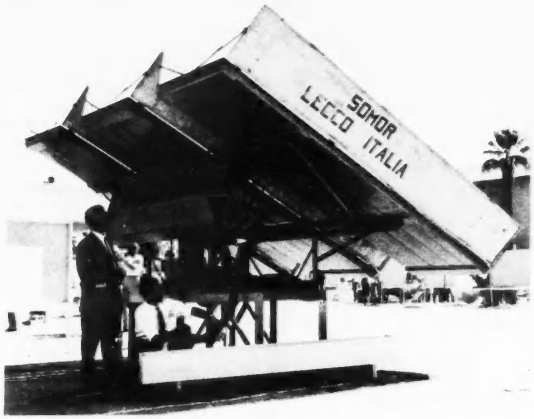


FIG. 3. This Solar Pump was built in 1951 by the Motor Company for the Recovery of Solar and Lost Industrial Heat, SOMOR, Milan. Water heated by the collector flows into a container. Two cylinders containing SO_2 are balanced on an arm. One cylinder, with liquid partly evaporated, is inserted into the hot water. The vapour then passes into the elevated cylinder whose outer surface is wet. Because of the evaporation from the outer surface, the vapour is cooled and condenses. This adds weight which causes the raised cylinder to sink into the hot water, raising the other cylinder. The process is repetitive.

Many models of a simple solar cooker have been successfully constructed so that the collecting surfaces concentrate the sun's rays on a spit or a cooking-vessel. Most of them have the shape of an inverted umbrella. The Indian Government has been intensely interested in these cookers and is now producing one in large numbers at a cost of approximately £5. Dr Telkes has recently developed a practical solar cooker at a cost of about £2. Mass production would reduce this cost.

Other uses of concentrating collectors in the middle temperature ranges include the operation of various simple mechanical devices by a generator where the sun provides the heat to produce the steam or vapour.

These generators have been successfully used to drive water-pumps for irrigation (Fig. 3), to run engines, and to produce electricity in limited quantities for other purposes. Such uses are experimental at present and relatively inefficient. Further research that may soon prove fruitful is under way in Egypt, India, Israel, the U.S., and elsewhere.

LOW TEMPERATURE

It is in the many low-temperature heat-using devices (below the boiling point of water) that the uses of solar heat are most promising. Solar water-heaters have been very effective (Fig. 4). Many have been developed in the U.S.A. (some 20,000 are in use in Florida); and the United Kingdom, France, India, U.S.S.R., Malaya, Israel,

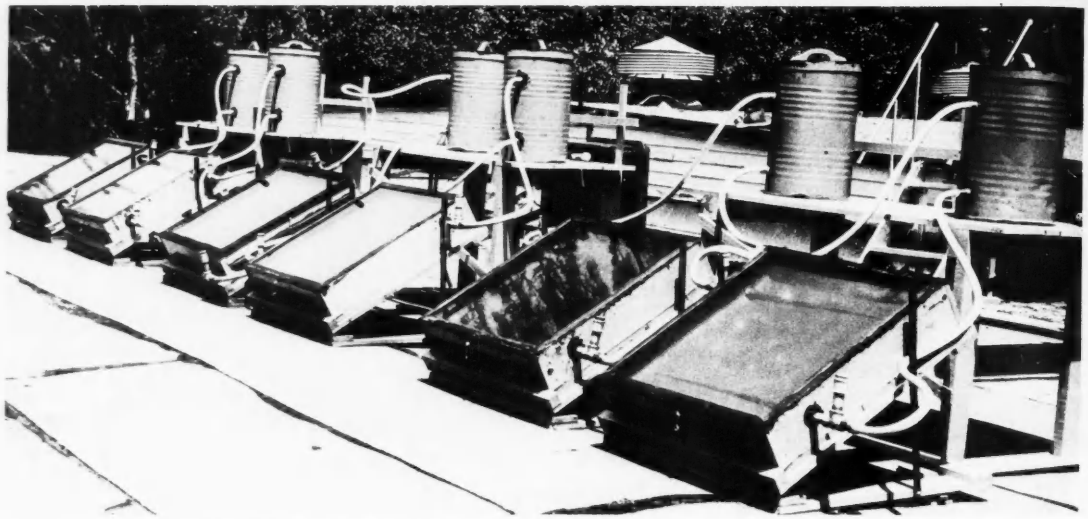


FIG. 4. Experimental solar water heaters at the University of Florida, Gainesville, Florida. Sunlight penetrates the glass covers of the flat collectors and heats their blackened absorbing surfaces. The absorbers in turn heat the water, which then flows by thermosyphon action to the storage tanks above.

Australia, and South Africa have also developed water-heaters.

In the U.S.A. the greatest interest in the application of solar energy has been in the heating and cooling of homes and small buildings. One of the first projects of the Godfrey L. Cabot Solar Energy Conversion Research Project at the Massachusetts Institute of Technology was to construct a solar-heated house. It was technically successful, though expensive (Fig. 5). Several other solar houses have been constructed. One of the first "solar" commercial buildings is in Albuquerque, New Mexico.

Solar stills to convert saline water to usable fresh water, and incidentally to secure certain mineral salts, have great interest for scientists in arid countries. A few solar stills use concentrating lenses or mirrors but are expensive and require complex design. Most solar stills use direct solar-heated evaporating trays with self-contained condensers. Dr Maria Telkes, of New York University, is working on a ten-phase distillation device which would greatly increase the production of water and perhaps reduce the cost to very close to competitive levels.

Considerable research attention has been given to improving the efficiency and lowering the cost of flat plate collectors. Improvements have been made both in design and in materials. One of the most recent flat plate collectors designed by Stanford Research Institute is illustrated in Fig. 6.

PHOTO-ELECTRICITY

The second potential use of solar energy is to create electricity (photo-electric). We have mentioned a limited possibility of producing electricity from small generators fuelled by solar heat. A much greater potential exists in the recent work of a number of university and industrial laboratories in developing photo-voltaic materials capable of converting a rather small percentage of solar energy directly into electricity. These converters are called solar batteries. One of the best known was developed by the Bell Research Laboratories (a photo-cell utilising silicon wafers), and is now being used in Georgia to supply about 50 watts of power to a rural telephone system (see DISCOVERY, February 1957, p. 69).

Other methods of direct derivation of electricity from solar energy including photo-galvanic cells are being studied with high prospects of useful results. Solar derived electricity will not be available in large concentrations for wide distribution in the foreseeable future. It will be in the form of small battery-type units, but it may well be suited to the needs of those nations with scattered, non-urban populations and limited industrial and commercial demands.

PHOTO-CHEMISTRY

Photo-chemistry is in its early research stages, but the scientists in the field believe its potential is enormous. Dr Farrington Daniels of the University of Wisconsin points out that the primary present research goal in photo-chemistry is to find a suitable reaction which can be produced by sunlight with the absorption of energy, and then be allowed to reverse itself at will in the dark with the evolution of energy.[8]

The great difficulty with all the solar heating or cooling devices which use flat plate collectors is the storage of solar energy for use at night and at other times when the sun is not shining. Various methods (including tanks of water or other liquids and pebble beds or bins) have taken care of heat storage overnight or for short periods with some success, but this remains one of the major problems. The Massachusetts Institute of Technology and some other solar research laboratories have been doing extensive research on the means

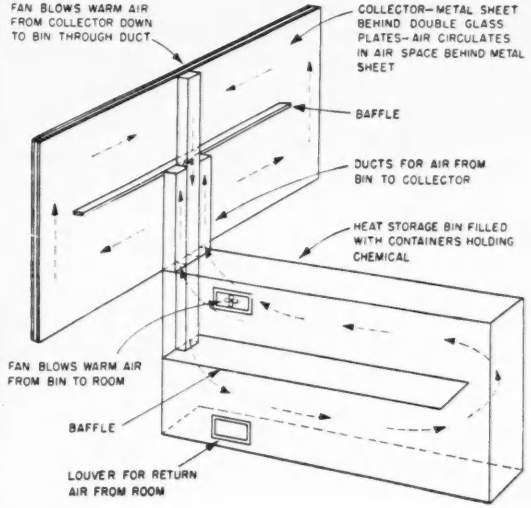


FIG. 5*a* (*top left*). This solar-heated house in Dover, Massachusetts, was built by the Massachusetts Institute of Technology in December 1948. It uses the heat of fusion of low-cost chemical compounds for storing solar heat. The chemical mixture consists of commercial anhydrous sodium sulphate, Na_2SO_4, mixed with the required amount of water and small amounts of additional agents to promote crystallization and inhibit corrosion. FIG. 5*b* (*top right*). Diagram of the collector and heat storage bin. FIG. 6 (*below*). This flat plate collector was designed by the Stanford Research Institute, California. Three features are: (1) the plastic film cover plate with light transmission characteristics similar to glass (now commercially produced, it withstands weathering and resists deterioration due to ultraviolet radiation); (2) aluminium (copper is also used) panels for the heat collector in which the tubing is integral with the metal sheet; (3) reflective insulation to minimize heat loss from the back of the plate.

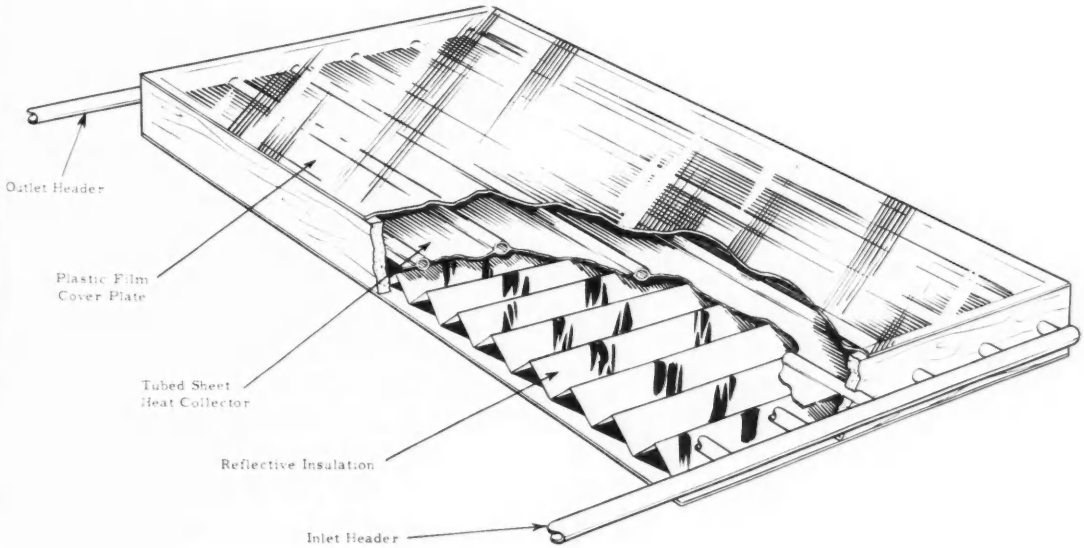


FIG. 7. This solar heated and cooled building was designed and constructed by Bridgers and Paxton, Consulting Engineers, Albuquerque, New Mexico, for their own use. The cost of this 4300 sq. ft. building was about £4 per sq. ft., which is equal to the average cost of comparable buildings in this area with all-year-round air conditioning. It uses radiant panels for heating and cooling and an air system for ventilation. (*Photo by courtesy of Bridgers and Paxton.*)

of converting solar to chemical energy with some encouraging results.

PHOTOSYNTHESIS

Photosynthesis is, of course, a photo-chemical process, but we have stressed it separately here because of its implications with respect to food production, perhaps the basic problem of the underdeveloped nations of the earth. Much attention has been given to the possibilities of mass production of algae as a source of food as well as fuel. Certain algae can be grown more rapidly than ordinary crops. *Chlorella* is one of the 18,000-odd species of algae which appears to be suitable for large-scale culture. It has been studied both on a laboratory and on an engineering scale in France, Japan, Israel, the U.S.A., and other nations.

There are some who believe that *Chlorella* fields could, perhaps, supply most of the food to the vastly increased populations of the future. It is claimed that the result could be twenty tons of protein and three tons of fat per acre per year. This far exceeds the present production quotient of land plants.

Important as this can be in the future, the possibilities of large improvements in photosynthetic processes in plants now marketed extensively for foods are more immediate and more exciting. Dr P. C. Mangelsdorf, in charge of the Cabot Fund for solar energy research on plants at Harvard, suggests that of the 3000 plant species used for food (150 of them in international commerce), only twelve now serve as the major food sources, and improvements in them would mean great strides in increasing food production.

The efficiency of the higher plants in using solar energy is potentially about as high as that of algae, but growing conditions usually prevent the potentials from being realised. It is believed that many of these difficulties can be resolved through research.

This brief review suggests that the effective utilisation of solar energy is just beginning. Much basic and applied research is necessary before major results can be secured, but we now know enough to see some of the directions the research must take and the potential value of this development. It is clear that solar energy is not a direct competitor either with the conventional fuels and hydro-electric power or with atomic energy in the provision of the basic power and energy requirements of an industrialised society. Rather it is a supplemental source of energy which can be of great significance, perhaps primarily in the economically underdeveloped nations. It may well be, however, that the unspectacular small-scale applications of solar energy suggested above will offer a more real prospect for steady improvement of the standard of living of the underdeveloped nations than some of the dramatic plans for atomic energy development.

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[2] "Transactions of the Tucson Conference on Solar Energy—the Scientific Basis", Tucson, Arizona, 1955, University of Arizona, Tucson, Arizona, 1957 (in the press).

[3] "Solar Energy Research", edited by Farrington Daniels and John A. Duffie, papers of the Symposium on the Utilisation of Solar Energy, Madison Wisconsin, September 12 to 14, 1953, sponsored by the National Science Foundation, U.S.A., and the University of Wisconsin, and published by the University of Wisconsin Press, Madison, Wisconsin, 1955, 290 pp.

[4] "Wind and Solar Energy", proceedings of the New Delhi Symposium, New Delhi, India, October 22 to 26, 1954, UNESCO Committee on Arid Zone Research, 19, Av. Kléber, Paris, 1956, 238 pp.

[5] *The Journal of Solar Energy Science and Engineering*, Association for Applied Solar Energy, Central Plaza Building, Phoenix, Arizona.

[6] *The Sun at Work*, quarterly newsletter of the Association for Applied Solar Energy (16 pp. each), vol. 1, nos. 1–4, 1956; vol. 2, no. 1, March 1957.

[7] Stead, William H., "The Sun and Foreign Policy", *Bulletin of the Atomic Scientists*, March 1957, vol. 13, Chicago, Illinois.

[8] Daniels, Farrington, "The Sun's Energy", *Scientific Monthly*, May 1956, vol. 82, no. 5.

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"MYXOS"—ANIMALS OR PLANTS?

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Most people must, at some time or other, have noticed a white creamy mass emerging from a living or dead tree or dry wooden post. At first it has a lumpy appearance and reminds one of some animal's brains. This mass, which may measure up to 2½ inches by 1½ inches, is a slime creature (*Reticularia Lycoperdon*) and consists almost entirely (90%) of pure protoplasm. In fact we might be looking at our primeval ancestor, "the slime of the earth". In a day or two its outer coat becomes dry or skin-like; and the mass of protoplasm now looks like a well-filled cushion and has turned a dark grey colour. A day or two more and the outer skin bursts and liberates millions of spores into the atmosphere, leaving in the empty case a few threads and reticulate strands like hairs.

HISTORY

It is just 300 years since one of these organisms was first mentioned and described and drawn by T. Panckow, and so it would seem an opportune moment to say something of their history. They acquired the rather repulsive name of Slime Fungi because at one period in their life-cycle they exist as creeping protoplasm; but in their final form they can frequently be objects of great beauty and delicate structure, as the illustrations show. They lie on the border-line between plant and animal life; now moving and feeding like amoeba, now producing spores like Pythium or Mucor. On the Continent they are usually called Myxomycetes, a name first given to them by a German, C. F. W. Wallroth, in 1833; but in the English-speaking world they are generally known as Mycetozoa, or fungus animals, following the interpretation of the German scientist of Belgian origin, Anton de Bary (1860).

The first illustrated monograph on the Mycetozoa appeared in 1875 in Polish. It was the work of J. T. von Rostafinski, a pupil of de Bary. A translation into English by E. M. Cooke was available two years later. That stimulated the interest of scientists throughout the world, and since that time there is not a single country that has not been combed for these little growths.

Since the publication in 1925 of the 3rd edition of "Mycetoza" (Brit. Mus. (Nat. Hist.)), three more species have been discovered that were formerly unknown in Britain, one in Sussex in 1932 (*Cribraria microcarpa*, Pers.), one in Norwich in 1934 (*Physarum rubiginosum*, Fries.), and the third in Aviemore in 1938 (*P. rubiginosum*, Fries.). A species entirely new to science was found in the palace gardens of the Emperor of Japan in March 1928, and has been appropriately named *Hemitrichia imperialis*, G. Lister.

But the name most particularly associated with the Mycetozoa, and rightly so, is that of Lister. The original monograph on the Mycetozoa was the work of Arthur Lister, whose name is perpetuated in the genus *Listerella* which Prof. Jahn named after him. He was already preparing the 2nd edition of this work when he died in 1908. It was, however, completed by his daughter, Guilielma Lister, who brought out the 2nd edition in 1911 and the 3rd edition in 1925. She was a naturalist of world-wide renown and did more than any other to classify the group and make them more easily recognisable by her detailed descriptions, drawings, and paintings. She named twenty-three species new to science and formed two new genera.

PLANTS OR ANIMALS?

To which kingdom do these creatures belong? Are they plants or animals? Scientists are not agreed on the subject; to some they are Fungus-animals (or Mycetozoa); to others they are classed as Slime Fungi or Myxomycetes. Let us consider briefly the pros and cons of these two names and see if we can come to a more definite conclusion.

These creatures begin their active life by emerging from spores as small particles of protoplasm, which soon develop a lash or flagellum by means of which they advance jerkily in the wet medium in which they find themselves. At this stage each one is known as a swarm cell and has several points of similarity with Copromonas (a minute parasite found in the rectum of frogs and toads): for instance, it has a flagellum, a contractile vacuole, and some food vacuoles. Very soon they cease their jerky movements, withdraw their flagella, and creep about in an amoeboid fashion. Then once again they extrude flagella and resume their dance-like movements.

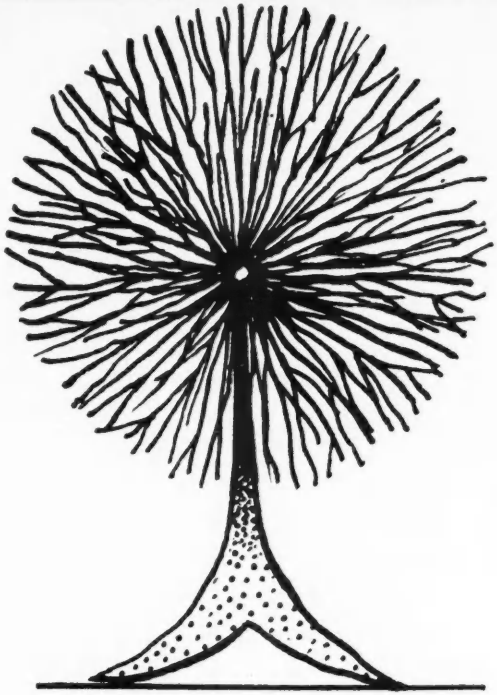
These swarm cells then divide several times mitotically and with a final withdrawal of their flagella they become amoebulae. The nuclei of these amoebulae now divide repeatedly, and with an investment of protoplasm form daughter swarm cells. Though apparently alike they are really dissimilar, since at this point they pair up in a sort of sexual process and form zygotes by a selective fusion. Each one has now the diploid number of chromosomes.

This mass of naked protoplasm starts feeding on decaying vegetable matter and bacteria and is known at this stage as a plasmodium.

Briefly the life-cycle of a Mycetozoon is as follows: Haploid spores→haploid swarm cells→haploid amoebulae; these unite in pairs and produce: diploid zygotes→diploid plasmodium→diploid sporangia. Here meiosis or reduction division occurs and haploid spores are formed and the cycle is complete.

FEEDING

The only essential condition of feeding appears to be the presence of edible matter, since some do better under hot summer conditions, others in the snow, and



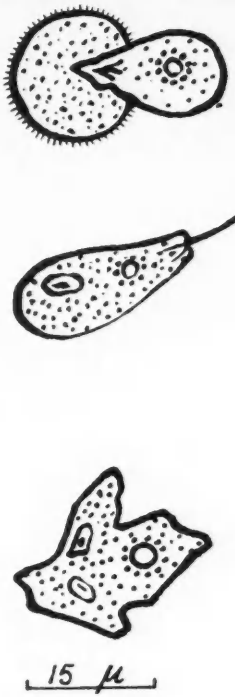


FIG. 1 (*left*). Lamproderma. FIG. 2 (*right*). Protoplasm emerging. *Top*, swarm cell emerging from spore. *Middle*, swarm cell free. *Lower*, amoebula.

others again prefer the humidity of autumn. They first of all devour any unpaired amoebulae and join up with other plasmodia of the same species they may come across; but plasmodia of different species never coalesce. All this is quite unlike anything we meet in plant life. Although some scientists regard these organisms as Slime Fungi, the very fact that they have a plasmodium separates them from the true fungi.

The plasmodia feed mostly on decaying vegetable matter. They send out shallow waves, or ripples of protoplasm, traversed by thick "arteries" in which a rapid flow of granular protoplasm can be observed, creeping in search of food. The whole is covered by a transparent coat of clear protoplasm which pushes out pseudopodia.

Another point which seems to show they have more affinity to animals than to plants is that, on contact with food, a stimulus is sent all over the protoplasm which at once converges rapidly to the source of nourishment, streaming through the main and branch "arteries" to the finest "arterioles" in the feeding area. Here it pauses for a minute or two as though taking in food, and then reversing, hurries back by the same route, making a second halt of shorter duration at its starting point, as though discharging the food collected. In each direction waste matter is egested and left on the substratum. We might compare this with the food-ward movement, confined to certain cells, in insectivorous plants.

In its digestion this organism also shows animal resemblances. For the most part the protoplasm is alkaline in reaction, but the presence of acid has been proved in the liquid of the food vacuoles dealing with protein matter.

Among the many differences between animals and plants there is not one that can be applied as an infallible test, because there is no clear line of demarcation separating the two groups. The best criterion is the method of feeding. Animals can take in solids and reduce them by digestion to simple substances, whereas plants can only take in simple substances and that in liquid form, which are then elaborated into complex substances and even into solids. The first method is that adopted by these slime organisms. Further, the complete absence of cellulose in their active state is another point strongly in favour of their animal classification; as it is almost invariably present in plants but practically unknown in animals. We can, therefore, unhesitatingly class them as animals and call them Mycetozoa or fungus animals.

Like the non-cellular animals, the Mycetozoa have a resting stage; but unlike amoeba which encysts when conditions are unfavourable, the Mycetozoa enter on their resting or sclerotium stage even in the presence of plenty of food and moisture. It may be that they have a definite period, or month of the year, when they will produce spore and so, in spite of favourable conditions, they will not do so until that time comes round. Many of them certainly do not produce sporangia except in certain particular months.

What is the explanation of this Jekyll and Hyde sort of existence in which they appear first as animal and then as plant? If all life has evolved from some initial protoplasm, when the bifurcation into plants and animals was reached, did some stay at the crossroads with, as it were, a foot in each camp, and never go any farther on the highway of evolution, exhibiting a novel form of alternation of generations in which a spore produces animal gametes which then unite to produce a sporophyte?

THE CAPSULE-FORMING STAGE

Before producing spores the plasmodium leaves its feeding ground and seeks a situation containing little or no moisture, such as dry leaves or twigs. Here it forms a capsule, either sessile or stalked, and pours into it a large number of spore mother cells. These capsules or sporangia usually contain some sort of capillitium (plates, threads, hairs) which help scatter the mature spore by the movements they make as they become dry. The size, colour, and marks on the spore are deciding features in classification. These usually take the form of spinules, spines, ridges, warts, or reticulation on the outer spore coat. This is the phase in which these creatures certainly look more plant-like than animal. For example in *Trichia decipiens* we find several characteristics which are the same as those met with in the liverwort *Pellia epiphylla*, an obvious plant. For instance, they both produce a capsule containing spore and yellow elaters with spiral thickenings. In this state, life seems to cease (although the spore is merely a resting stage), and they may be collected and kept for years.

SOME INTERESTING SPECIES

Most of the Mycetozoa are of microscopic proportions, but there are some large enough and striking enough to catch the ordinary eye. For example, there is *Fuligo septica*, perhaps the best known of all British species as it has a popular English name. On account of its frequent appearance in leather factories, it is known as "Flowers of Tan", where its bright lemon-yellow colour stands out conspicuously against the dark background of the spent tan.

Another very large species that may be met with in woods and copses is *Brefeldia maxima*, its creamy plasmodium sometimes creeping two or three feet up a small holly bush or cluster of elm suckers and completely investing them. Others that are individually very small may yet be quite noticeable on account of their vast numbers. For instance, *Lamproderma scintillans*, so named because of its shining metallic outer coat, is a very beautiful thing, with capillitium threads radiating from the tip of its stalk. It is a hardy, flourishing little species, not particular when or where it appears. It sometimes grows in great profusion, covering several square yards with thousands of sporangia, forming up on anything that happens to lie in its path: leaves, wood, stones, brick, and so on.

The pretty little chalice-like coloured cups of the Arcyria group are also likely to be a familiar sight, as they give a decorative effect to any old log. I once saw a pine log 4 feet long and 9 inches in diameter covered with thousands of sporangia of this type, yellow forms and the more usual orange-red occurring in the same development. All forms of Arcyria have a close network of capillitium (which expands in the breakdown of the sporangial wall) emerging from the cup-like base adorned with various markings.

LOOKING FOR SPECIMENS

In an insect-proof case Mycetozoa can be kept indefinitely in all their original beauty of form, and often of colour too, when they have passed from the slimy stage to the mature spore-bearing stage. There are about

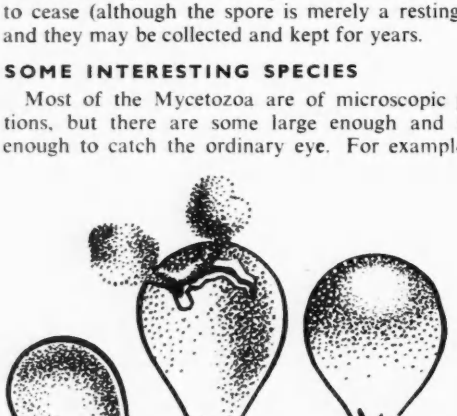


FIG. 3. Hemitrichia.

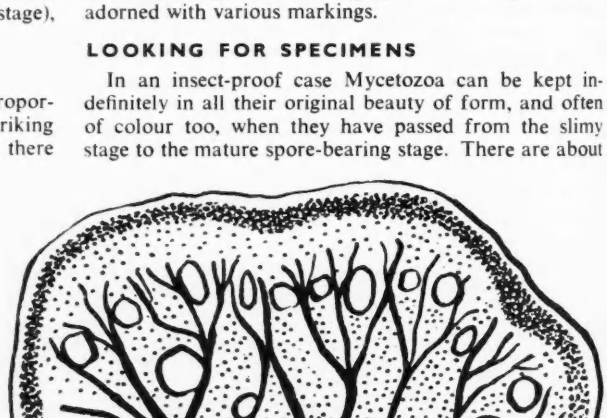


FIG. 4. Creeping protoplasm.

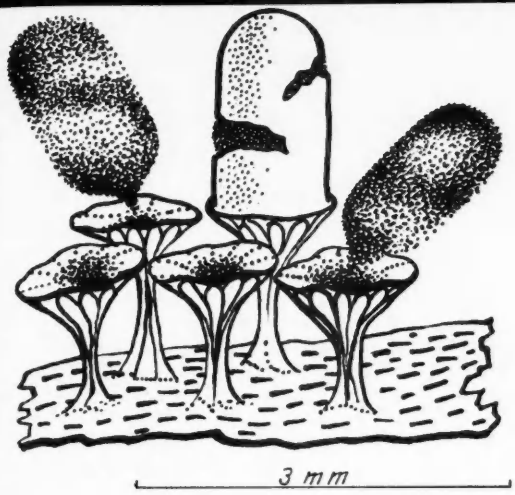


FIG. 5. Arcyria.

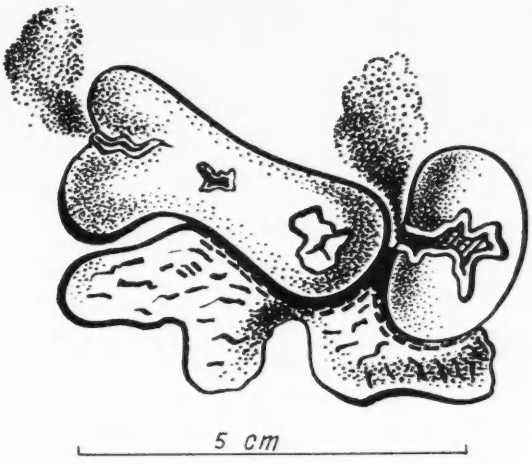


FIG. 6. Lycogala.

200 species of Mycetozoa native to Britain and of these no less than 130 have been found in Surrey alone.

Experience has shown that much precious time may be lost by looking for specimens at a time of the year when they are not likely to be found, or in situations where they have never yet been met with; and so some record of dates and habitats would be a most useful, though not infallible, guide to those who would like to make a field study of these fungi. Although some can be found at any time of the year, October and November are the most prolific months. Only a few species have been found on living trees; they prefer dead logs, stumps, branches, twigs, and leaves.

Conifers provide the most frequent habitat, accounting for 48 different species. Poplars are second with 35 species, then oak (29), moss and lichens (29), beech (26), holly (24), lime (21), elm (17), laurel (16), alder and bramble (15), old straw (13). With ten or less to their credit are yew, ash, *Quercus ilex*, hornbeam, horse chestnut, Spanish chestnut, sycamore, tulip tree, elder, willow, and birch.

The "Myxos", as their devotees familiarly call them, are classified according to outward appearance, the composition of the sporangial wall or walls, the type of capillitium, and the size and markings of the spore. There are two main divisions, depending on whether the spores are inside a case or capsule, or naked and exposed. The Exposporeae have naked spores borne on the outer surface of the sporophores. The only example of this kind is *Ceratiomyxa fruticulosa*, Macbr., which is found frequently from March to October on rotting lime boughs, alder, birch, pine wood, and some others. The branching sporophores frequently resemble a four-fingered glove erect. All the other Mycetozoa have spores contained in some sort of capsule or sporangium and hence are called Endosporeae. These are further divided into sub-orders according as their spores are dark or brightly coloured.

For the successful study of the Mycetozoa, one should have the use of a good microscope. When out on a foray, it is essential to carry a strong hand lens. If this is hung round the neck or attached to a button-hole, it will leave both hands free for collecting. A stout pocket-knife is needed for removing specimens from logs and a number of small boxes to receive them. Matchboxes will do quite well for the smaller types. Place your find in a cylinder of tissue paper and put it in a matchbox until you get home; or, better still, have boxes lined with cork or felt and a supply of pins for fixing them in position. Strong boots, leggings, and leather or carpet knee-pads, together with a hammer and chisel, are also useful adjuncts.

I am sure there would be many more devotees of this study if they realised how absorbingly interesting it is. This form of recreation can truly be called an all-the-year-round hobby and, because of the multifarious habitats of these little creatures, it can be indulged in almost anywhere.

I have lifted the snow to find *Lamproderma* and *Craterium*, I have seen the little gold specks of *Trichia lutescens* shining through the icy coating of a rotten alder branch. In dripping rain, but clad accordingly, I have collected *T. alpina* and *Colloderma*, and, under burning sun, *Lycogala* and *Fuligo*. Even the bleak winds of March and April fail to prevent the appearance of *Dianema* and *Diderma*. With such a hobby we need never know a dull moment.

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HEAT TRANSFER WITH LIQUID SODIUM

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The increasing use of high temperatures in industrial plant has created a need for better heat-transfer media. As a result the development of liquid metal coolants has been intensified in recent years. In general, orthodox liquid coolants cannot be used above about 300°C and for higher temperatures the sensible heat of liquid metals has to be utilised.

The most important new industrial application of high temperature heat transfer is the removal of heat from nuclear reactors. In a reactor such as the fast fission reactor at Dounreay, the heat source is compact but intense, and ratings approaching 3 million B.Th.U./ft²/hr. are expected. This imposes a heat-transfer problem several orders of magnitude greater than any other so far encountered industrially.

The properties of a metal which determine its choice for heat-transfer usage are: (1) freezing point, (2) liquid range, (3) chemical reactivity, (4) cost and availability, (5) toxicity, (6) inflammability. In addition to these, for nuclear reactor work neutron capture, nonreaction, and stability under irradiation are important. Considering these properties generally, the eutectic mixture of sodium and potassium is the most acceptable, but its high cost and non-availability in Great Britain has resulted in it being superseded by pure sodium.

None of the empirical heat-transfer equations developed for water and similar media can be used with liquid sodium because of the latter's quite different physical properties. The Prandtl Number, which characterises the heat-transfer properties of a fluid, is about 0·7 for most fluids, but for liquid sodium it is about 10^{-2}. In addition, liquid sodium does not wet the heat-transfer surfaces. Specific empirical equations have been obtained for sodium, but the results are not, as yet, very reliable. In all cases the heat-transfer coefficients are extremely high.

Of the factors influencing design of equipment, the choice of materials of construction is perhaps the most important. Pure sodium-potassium mixtures are non-corrosive to pure nickel and some stainless steels, but in the presence of even traces of metal oxides, liquid sodium alloys attack rapidly all feasible structural materials. It is therefore necessary to eliminate all oxides from any system using these coolants. The solu-

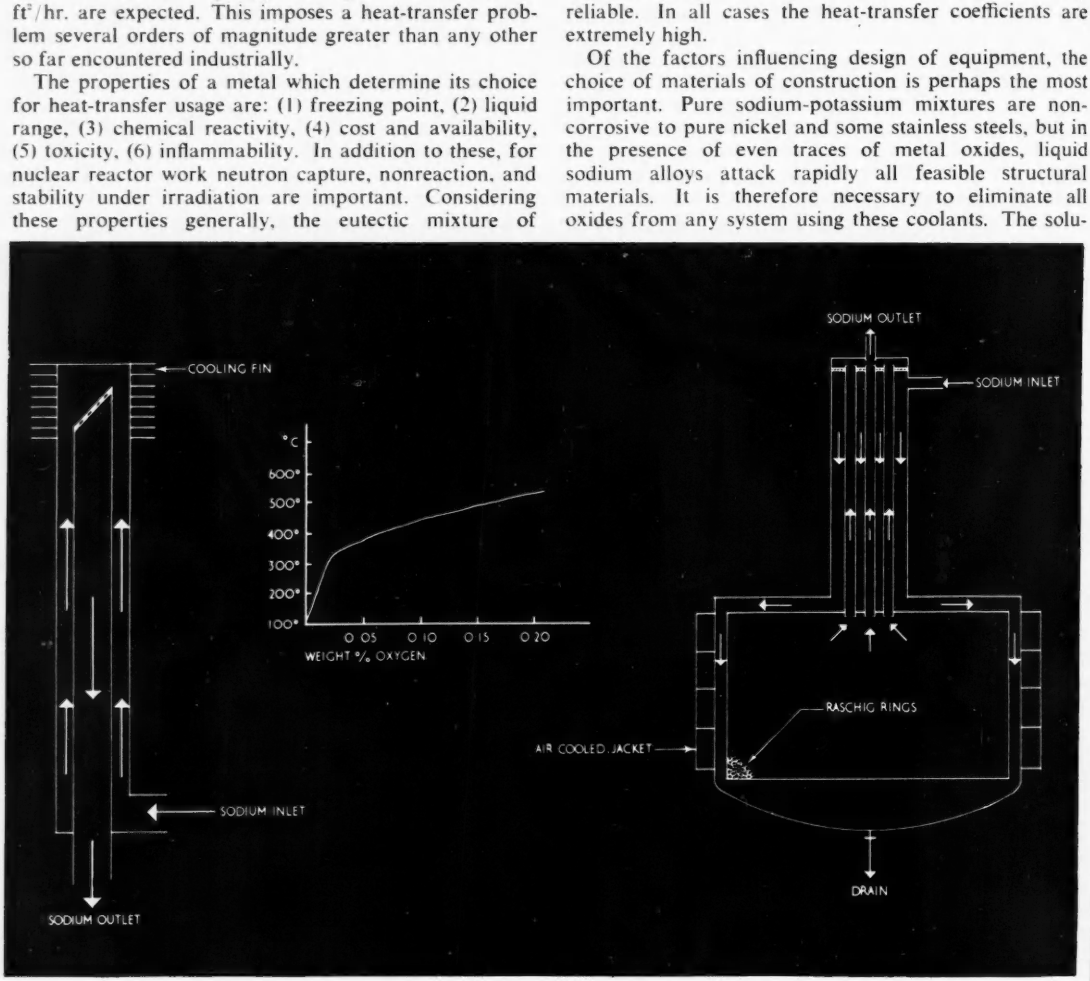

FIG. 1. The solubility of oxygen in sodium.

bility of sodium oxide in sodium increases rapidly with temperature, and by cooling the sodium, and passing it through a filter, the oxide can be precipitated and removed. Normally a bypass filter with stainless steel packing, such as shown in Fig. 1, is used, the whole charge being treated about twice an hour. A refinement of this technique can be used to measure the sodium oxide content of the metal.

One aspect of corrosion peculiar to liquid metal handling is the dissolving of the structural metal at hot parts of the system and subsequent deposition in cooler regions. This material transfer is a purely physical action, and may cause troublesome blockages in the system.

The heat from the sodium has often to be transferred to water before it can be usefully employed. Because of the violent reaction between sodium and water, the use of a standard shell and tube heat-exchanger is inadvisable. Two alternatives used are: (1) water and sodium flowing through two separate tubes thermally connected by metal webs, or (2) concentric double-walled tubes inside a shell, the annular spaces being purged by an inert fluid to detect any leakages.

The entire plant is normally constructed in nickel or stainless steel, and welded throughout. If a demountable joint is required, a flanged joint with a copper "O" ring is satisfactory. Standard bellows-sealed glandless valves

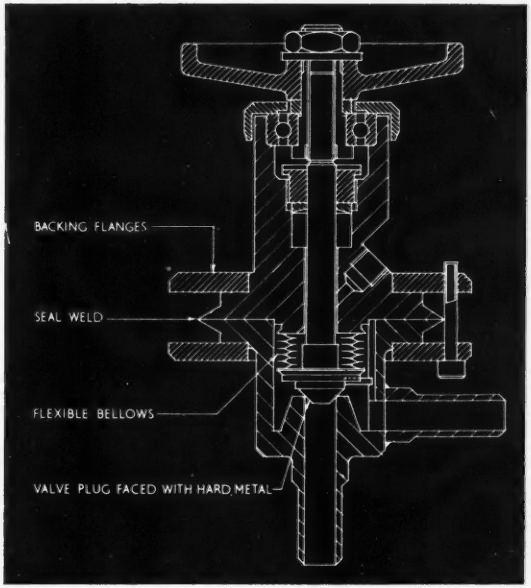

FIG. 2. Standard bellows-sealed glandless valve.

FIG. 3. Ball-race after running in sodium.

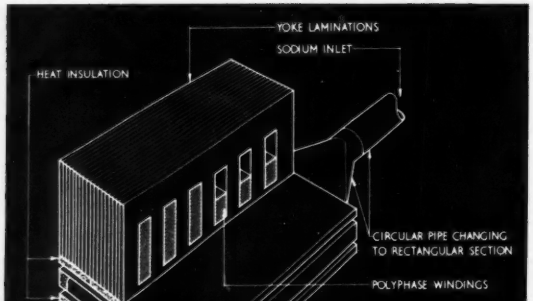

FIG. 4. Electromagnetic pump.

FIG. 5. Liquid metal-flow meter.

are used, as with other reactive fluids where no leaks can be tolerated. (Such a valve is illustrated in Fig. 2.) A simple alternative to a stop-valve is to freeze the metal in the pipe. The design of pumps is complicated by the necessity of isolating the liquid metal from the pump mechanism. Any gland-packing material would be attacked by the sodium, though the use of a frozen sodium seal on the pump shaft has been suggested. Two methods of obtaining a completely sealed system have been used. In the glandless mechanical pump, the impeller and driving rotor of an induction motor are enclosed in a common housing, the field winding on the rotor being sealed from the motor armature by a thin annular shell. Great difficulty has, however, been experienced in designing bearings to operate in liquid sodium, which is a very poor lubricant. One example of a ball-race which has been run in sodium is shown in Fig. 3. A more elegant design of pump utilises the fact that, since sodium is a good electrical conductor, the eddy currents induced by varying electrical and magnetic fields can be made to move the liquid. In this type of pump (Fig. 4) there are no moving parts in contact with the liquid metal. The same principles are also used to measure the rate and flow of sodium in a pipe. In this case, the liquid moving in a steady magnetic field produces eddy currents which are measured and calibrated in terms of flow rate. The arrangement is shown in Fig. 5.

During operation, sodium heat-transfer systems are always completely sealed from the atmosphere, any free space above the liquid being blanketed with an inert gas such as argon, helium, or nitrogen. The slight reactivity of the latter can often be tolerated because of its cheapness. During the initial filling of the system, formation of corrosive metal oxides must be avoided as far as possible. Fortunately both stainless steel and nickel are inherently free from surface oxide films, but even with these metals it is sometimes advisable to pickle or even polish before use. Before filling, evacuation of the system, followed by inert gas purging, minimises the atmospheric oxidation, any small amounts of oxides which do enter the system being removed during operation in the bypass filter.

Removal of residual amounts of liquid metals from apparatus before maintenance needs special techniques. The normal laboratory method of removing sodium by reacting with alcohol is not advisable because troublesome soapy addition compounds are formed. Anhydrous liquid ammonia is the only true solvent available for sodium. This can be used for cleaning, but is restricted to small items, due to expense and high pressures (150 p.s.i.) required.

The method found most satisfactory for large equipment is a controlled reaction with low-pressure steam, the hydrogen evolution providing a measure of the reaction rate. The use of water sprays invariably results in fires, and must be avoided. In general, however, the fire hazards with liquid sodium are much less than originally feared. In dry conditions, hot sodium burns quietly in air and is readily quenched with special powder extinguishers available commercially. If any water is present, a much more violent reaction, with large flames, occurs. Safety precautions in appropriate cases therefore include controlled atmosphere, exclusion of water and, when necessary, suitable protective clothing. The use of liquid metal cooling has been pioneered by the atomic energy industry, but as experience and confidence in handling these unusual media are acquired other industries will certainly find applications to their own heat-transfer problems.

ACKNOWLEDGMENTS

The bulk of development work on liquid sodium handling has been done in the Capenhurst and Windscale Laboratories of the Research and Development Branch of the Atomic Energy Authority (Industrial Group) to whom I am indebted for much of the information given here.

Acknowledgment is also made to the Managing Director of the Industrial Group, U.K.A.E.A., for permission to publish this article.

PSYCHOLOGY AS A BRIDGE BETWEEN ARTS AND SCIENCE

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Is our educational system really attuned to the age? With this question Sir Henry Tizard challenged a recent conference of the Science and Industry Committee of the British Association. No one present thought so. Nor do a great many non-members of the Committee. In particular, the belief is growing that the venerable horns of our academic dilemma—Arts *or* Science—are preventing those harmonious studies that should be cultivated by the citizen of tomorrow. On the one hand, the young graduate in science is accused of being culturally illiterate; the young biologist who came to Prof. Mace to study psychology on the ground that she knew everything that went on inside the rabbit but nothing whatever of what went on outside it must have been aware of some such shortcoming in herself. On the other hand, graduates in Arts are thought to be ill-fitted for many administrative posts in industry and government which require a sound grasp of the basic problems and procedures in some *definite* branch of science. No doubt a variety of measures may be necessary to deal adequately with the situation. The projected new Tripos at Cambridge is one such attempt, and the proposal I put forward here is intended to be another. It is that the curriculum for students of Arts and Science alike should include a subject which combines scientific rigour with a humanistic content. It seems to me that psychology, properly taught, might qualify as such a "bridge-subject" between Arts and Science.

POLYMORPHOUS PERVERSE

To a certain extent this is already the case. The many-sided role of psychology at the university is acknowledged in the fact that it is one of the few subjects which is taught in several faculties, though the cynic may describe it, like Freud's infant, as "polymorphous perverse". At Manchester, for example, the Department of Psychology is primarily part of the Faculty of Science. But it also belongs to the Faculties of Arts, Medicine, and Social Studies, and it is closely associated with the Faculty of Education. It has links, too, with the Faculties of Law, Theology, and Music through a mutual interest in—respectively—criminology, religion, and aesthetic appreciation.

BLISS AND BIOLOGY

The claim to status as a "bridge-subject" does not, however, rest on convenient academic arrangements. It has a more solid foundation in the nature of psychology itself, which occupies a strategic position between scientific and humanistic studies. As good a claim, perhaps, could be made for regarding psychology as a branch of theology as of biology, though if Ortega y Gasset, the great Spanish philosopher, is right, these two branches of learning are not as far apart as we are accustomed to think. For he wrote: "Bliss, in the theological sense, has distinct biological features, and on the day—not, perhaps, as far distant as the reader thinks—when a general science of biology is constructed, in which current biology will be only a section, the fauna and physiology of heaven will be defined and studied biologically, as comprising one of so many 'possible' forms of life."

At any rate, from the point of view of the theory of evolution, the student of psychology must begin with a grounding in paleontology, ethology, and human genetics. This must be followed by an introduction to neurophysiology (including a study of the special senses), which presupposes an acquaintance with physics and chemistry, at least to advanced level in the General Certificate of Education. A knowledge of the physics of light, sound, and electricity will also be essential at a later stage when the student will be initiated into the mysteries of psychological experiments. Here he will require some mathematics as well to enable him to employ techniques of statistical design and analysis with the necessary competence.

MEN'S INFLUENCES

But if psychology can trace its lineage on its "father's" side to the biological sciences, it can claim, on its "mother's" side, next of kin among the social sciences and the humanities. Those who aspire to become psychological scientists overnight fondly imagine that everything mental can be known, at any rate eventually if not now, by a study of the brain. In my view, the truth is very different. Human experience is distinctive, never to be reduced to or derived from the electro-chemistry or physics of the brain. The triple roots of our experiences lie in our *human* nature, in our individual life histories, and in our cultural histories. Man is not merely an "open system" in the thermodynamic sense. He is *wide* open to influences that fall outside the domain of science, however broadly and generously this is defined. He is open to influences of an historical, aesthetic, ethical, literary, mythical, and religious nature, of which the sciences as such know nothing but which fall well within the scope of psychology.

I would be prepared in this context to raise the allied question: What form of introduction to scientific ways of thought is most congenial for the young mind? The answer this question deserves would, I believe, require a thorough scrutiny of pedagogical and parental influences in infancy and childhood. But let us restrict ourselves to adolescence. It might be supposed that to cram a boy

with scientific "facts" and make him repeat in routine and quasi-magical fashion a series of stereotyped experiments is not the best way to prepare him for a career in science. A disciplined training in historical, classical or literary studies may serve the purpose better.

The hazards of a so-called "scientific" training at school may be illustrated by an example from my own experience. Not long ago a grammar school student came to seek a place in the Honours School of Psychology at Manchester. He chose this particular subject, he said, because at his grammar school he had been trained in the natural sciences—mathematics, physics, chemistry—and he wished to come to the university to study the occult sciences, of which psychology, he thought, was one. He did, indeed, display a commendable familiarity with the various occult "sciences"—palmistry, phrenology, astrology, clairvoyance, crystal-gazing, and numerology. Is it not disturbing that this bright boy could receive intensive training in science for six years at a first-rate grammar school and yet be totally unable to distinguish the genuine scientific article from the many bogus substitutes?

A century ago, Mary Boole, the wife of the celebrated mathematician George Boole, suggested that a thorough grounding in Latin may be a better preparation for the future scientist than learning "science" at school, for the student of classics must interpret opinions held by writers of antiquity on physics, medicine, natural history, and astronomy without having to accept these opinions. Such experience, she thought, could be an "excellent corrective of that shallow up-to-dateness which is the vice of modern pseudo-scientism". This statement has its edge even today. It may be added that the painstaking integrity and powers of imaginative interpretation which mark the true scholar are not the prerogative of the professional scientist, any more than bias, dogma, and obscurantism are the monopoly of the savant of the humanities.

A TWOFOLD PLEA

I conclude, therefore, with a twofold plea: first, for reconsidering the relative influence of humanistic and conventional scientific studies at school on the future scientist; and second, for giving both Arts and Science students at the university instruction in a subject such as psychology, which joins an empirical study of natural phenomena with an appreciation of the "splendour and misery" of man, as embodied in his history and aspirations and in the abundant products of his inexhaustible imagination.

THE MOSCOW INSTITUTE OF GENETICS

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The Moscow Institute of Genetics, which I visited this August, is known as the storm centre of unorthodoxy—some would say of heresy—in biology. In 1948 the Institute's director, Academician T. D. Lysenko, precipitated a pitched battle probably unmatched in scientific history since the 19th-century clash between T. H. Huxley and Bishop Wilberforce as to whether man was descended from ape or angel. The crux of the controversy is whether or not the "inheritance of acquired characters" is a possible and normal occurrence, or whether, as "Mendel-Morganist" genetics has traditionally maintained, the role of the environment is restricted to accelerating or retarding an intrinsic process of random "mutation".

HEREDITARY TRANSMISSION VIA GRAFTING

The most spectacular evidence claimed by Lysenko's school of "Michurinist" genetics concerns the hereditary transmission in plants of characters acquired from other varieties onto which they have been grafted. If this phenomenon is genuine, it is generally conceded that a profound revolution is required in genetical theory. But, as I emphasised to Lysenko as soon as discussions with him and members of his staff had begun, "graft hybridisation" (leaving aside the work of the French botanist Daniel* in the early thirties) has never been accepted or satisfactorily repeated in the West.

The conversation naturally turned to the possibilities of clearing up the contradiction by exchanges of scientific workers between laboratories in East and West. Lysenko declared himself in favour of such exchanges on general grounds, but thought they would be of little use in solving the graft hybridisation mystery. His reason was that some of the graft hybridisation experiments were so simple that the doubter could perform them in his own laboratory easily enough, without needing a Russian to show him how.

I challenged him to describe such an experiment. He at once suggested one in barley, which he claimed could be done in five minutes. An embryo from an awned variety is grafted onto the endosperm of an awnless variety. If the resulting adult plant is self-fertilised, a proportion of the progeny, Lysenko claimed, will be awnless, and will transmit the trait to further generations.

The particular varieties used were immaterial, he asserted, provided that the graft was from an awned, and the stock from an awnless, variety. The technique was simple and well known. He was quite prepared to guarantee positive results.

* See the bibliography of Hudson and Richens, "The New Genetics in the Soviet Union", Cambridge, 1946.

Lysenko autographs a copy of his recent essay, "Biological species and species-formation", at the end of the discussion. The cherries and strawberries on the table were grown on the 60th parallel near Leningrad.

EXPERIMENTS ON WHEAT AND CATTLE

The activities of the Institute were then described to me, starting with work which is being carried out under Lysenko's personal supervision—namely transformation of spring varieties into winter varieties of wheat and raising the butter-fat percentage in dairy cattle.

The latter programme consists in special feeding during pregnancy of local cows crossed to Jersey bulls. After the calves are born, all are fed and treated alike. Yet the plane of nutrition on which their mothers were maintained during pregnancy seems strongly to affect the butter-fat percentage of the milk which the daughters give when they grow up. After low-plane treatment they give the 3%–4% butter-fat characteristic of the maternal breeds, but if their prenatal existence has been nutritionally privileged they reach the 5%–6% level of Jersey cows.

In addition, Lysenko said that he was engaged in theoretical studies on problems of adaptation, ecological adjustment, and the origins and interrelations of species.

Members of the staff of the Institute who were present included Nuzhdin, who heads the radiobiological section; Kushner, who directs the poultry-breeding programme; Kosikov, who is in charge of the work on microbial genetics; and Sukhov, who is responsible for the virological section. Glushchenko, whose work on graft hybridisation in tomatoes forms a major evidential plank in the platform of Michurinist genetics, is head of the section of plant genetics but was unfortunately away at the time of my visit.

POULTRY GENETICS

The work of the various sections is fully covered in the periodical bulletin published by the Institute. I shall confine myself here to some of the work done by Kushner's section of poultry genetics, since it is nearest to my own work and interests.

The emphasis of this work is, as would be expected from the general trend of the Michurinist school, strongly environmentalist. For example, a long-term experiment was started in 1947 on the cumulative influence of diet from one generation to the next. A flock averaging 1800 grammes adult body-weight was divided into two groups, one maintained on a high and the other on a low nutritional level. After three generations the average weight of the first group had risen to 2100 grammes, while that of the second group had fallen to 1300. Egg-production figures for the two groups at this stage were 140–150 and 12–15 eggs per annum respectively. Beginning with the fourth generation, both groups were fed alike. The difference in body-weight did not immediately vanish but persisted in diminished, but statistically significant, form for three further generations.

Whatever its theoretical significance, the practical bearing of this result on poultry farming is clear enough. The interpretation favoured by Dr Kushner was that the direct bodily effects of high and low planes of nutrition during the first three generations had in some way become fixed in heredity, so as to be transmitted in some degree from parent to offspring in the following generations.

I suggested that a more orthodox interpretation could be salvaged in terms of natural selection—genetically slow-growing types being presumed at an advantage on a poor diet and hence more likely to reproduce their kind, and vice versa on the abundant diet. I agreed that the fairly elaborate design of the experiment made this rather unlikely, but Dr Kushner conceded that it was in principle a possibility.

Kushner's experiments with blood transfusion in poultry seemed to me more difficult to criticise along such lines. He had subjected White Leghorn hens to twice-weekly transfusions of blood—in one group using New Hampshire donors and in another group wild duck. Crossing the treated hens to pure White Leghorn cocks he obtained about 10% chicks marked with a single coloured feather. In the next generation the same procedure was repeated, and now some chicks appeared with coloured plumage over their entire body surface.

Pure white chicks taken from this batch and crossed *inter se* without transfusion treatment also threw a proportion of coloured progeny. There were two types of controls: untreated White Leghorns, and White Leghorns transfused with White Leghorn blood. Both gave less than 3% birds with a few coloured feathers. The control transfusions were discontinued after the first generation. A repetition of the experiment will be started this year using White Plymouth Rock hens.

A recent French report* described similar results obtained by injecting nuclear extracts from one breed of ducks into another. Whatever the final verdict on this particular work, there is little doubt in my mind that inherited changes brought about by the non-sexual transfer of material from one genetic type to another will eventually become generally recognised in the West as valid for higher animals and plants. The process is already well known and beyond controversy in the case of micro-organisms.

REUNITING GENETICISTS

When this occurs there is a risk that the reactions of geneticists on both sides of the fence may be undignified. The Michurinists, who have been publishing results of this type for decades, may clamour: "We told you so!" The geneticists of the West may simply ignore the claims of Russian and other workers of the Lysenko school to be given the credit for the first demonstration of the phenomenon.

The only certain remedy that I can see is to reunite the genetical profession in a single scientific brotherhood irrespective of politics, nationality or genetical creed. Old insults and injuries must be forgotten by both sides, and attention must be concentrated on what is new, valuable, and invigorating in each school of thought. In more definite terms, Soviet and East European biologists must be willing to publish in Western journals and vice versa. More opportunities must be found for personal meetings at conferences and symposia, and more exchanges must be arranged between individual scientific workers for periods of study or experimental work.

I argued all these points with energy and persistence during my stay in the Moscow Institute. I found the Director and his staff generally in sympathy with this point of view but sceptical of the amount of goodwill upon which they could count from the Western side. A similar scepticism in reverse prevails here. Someone has to take the first step.

* See Benoit, J. *et al., C. R. Acad. Sci., Paris,* vol. 245, pp. 448–51. *The New Scientist,* May 16, 1957.

THE BRITISH ASSOCIATION

The first important event at this year's British Association meeting in Dublin was the election of Sir Alexander Fleck as President for 1958. A Fellow of the Royal Society, who is also Chairman of Imperial Chemical Industries, Sir Alexander is the third President to be chosen specifically for his contribution to industry. The first was Dr C. W. Siemens (1882), and the second Sir Charles Parsons (1919).

Sir Alexander's election reflects the B.A.'s integration with modern life and the growing part that science is taking and must take in the development of industry. When 250 scientists travelled by stage-coach to York 126 years ago for the first B.A. meeting, the Industrial Revolution was in its merest infancy. Since then industry has become respectably established, and today's revolution may be termed technological, since more and more the modern age is requiring highly skilled experts in highly specialised subjects.

But it is also increasingly important that the layman should know at least the principles upon which science works, and the general trends and possibilities, both theoretical and practical. In the dissemination of such knowledge the B.A. can play an important part. Prof. Blackett's address (DISCOVERY, *September, p. 373) brought to the attention of the public the importance of science and scientifically based economics for under-developed countries. Sir Alexander Fleck's next year will no doubt stress the importance of science to industry.*

As industry today is gaining so much from science, it is only right that it should help to finance the future of science, and forward-looking firms are well aware both of the obligation to do so and of the benefits to be derived. The B.A. has thus turned to industry to help them replenish their funds, and £40,000 has already been received from a small number of industrial firms. This gives an additional £8000 income for the coming year, and nearly doubles the income of the Association.

Ireland

Naturally, with the B.A. meeting taking place in Dublin, interest was centred upon Irish themes. Mr G. F. Mitchell gave an evening discourse on Ireland in antiquity, the earliest archaeological site being dated at 5700 B.C., though knowledge of cereals and of domestic animals did not reach Ireland till 2500 B.C.

Prof. O'Kelly of Cork has made a study of the available evidence of prehistoric smelting and has been able to establish the type of furnace commonly used in Britain and Ireland. Such a furnace consisted of a small pit scooped in the ground, about one foot in diameter and about a foot deep. This was usually lined with clay plastered on to the sides and bottom of the pit. Fixed on one edge was a funnel-like piece of clay, the open end turned outwards from the pit, the narrow end pointing inwards and downwards over the edge. The central hole through this was about one inch in diameter. Fragments of these blast-holes or *tuyères* have been found on several excavations. The ends of the blowpipes from a pair of bellows were in action, the forced draft from them was directed down into the pit. Wood charcoal was charged into the pit and set alight. Layers of soft ore, such as limonite or bog-ore and charcoal, were spread over the burning fuel; and when the furnace was fully charged a clay dome was built over the top, leaving a small hole at the centre for the escape of the gases.

Ireland being an agricultural country, the theme of this year's B.A. was directed towards this subject. Pointing to the pattern of Irish agriculture, Dr J. N. Greene, President of the National Farmers' Association, explained that farms are usually under fifty acres, of which 80% is in grass production. The present policy of Britain in giving preferential treatment only in the case of store cattle and store sheep tends to maintain this type of agricultural pattern and consequently aggravates demographic and social problems. At present the gross output of Irish agriculture is only £15 per acre, which results in the majority of Irish farmers living at little above subsistence level. It is necessary to increase this output to a point where each acre would return a nett family income of £16, to remunerate labour

input and investment. Such a standard of prosperity for Irish agriculture would result in a greater export volume of agricultural produce and thereby increase British industrial imports. Such a flourishing agriculture would allow for a greater development of industry and would ultimately result in a properly balanced Irish economy. This could be achieved by improved trading facilities for all agricultural commodities exported to Britain from this country, and would make it possible for Britain and Ireland jointly to provide more of their basic agricultural needs.

Nuclear Fusion for Power

J. D. Lawson gave an excellent paper on nuclear fusion. He said that if we can discover how to burn the heavy hydrogen in the oceans to helium in an efficient manner, the world's fuel problem would be solved. Physicists are studying the problem, and there is to be a session devoted to it at next year's "Atoms for Peace" conference at Geneva.

Fusion reactions between ordinary light hydrogen nuclei (protons) are important in the stars, but would be almost undetectable in any conceivable terrestrial system; reactions employing the heavy hydrogen isotopes deuterium and tritium on the other hand are about 10^{25} times more probable. A mixture of deuterium and tritium is by far the most "inflammable" fuel; unfortunately, tritium does not occur naturally. It can be bred by capturing the neutrons emitted during combustion in the light isotope of lithium, which decays into tritium and helium. Lithium is not a common metal (reserves are probably comparable with those of uranium), and our ultimate aim must be to use a cycle based on deuterium. The reaction rate of this cycle is about 100 times less than that for the tritium-deuterium cycle, and the problem of making a power-producing system is more difficult.

Temperatures of a few million degrees are necessary for fusion reactions to be detected, but for appreciable power to be produced at least a hundred million degrees is necessary. At such a temperature the gas is completely ionised, that is, it consists of nuclei and free electrons. Such a gas (which has been called the "fourth state of matter") has many interesting properties: it is an excellent conductor of electricity and it is profoundly influenced by magnetic fields. It is in the exploitation of these electrical properties that the hope of isolating such a gas from the walls of its container lies.

The central problem, however, is not that of producing a hot gas (difficult though this is), but of devising a system which produces more power than it consumes. A fission system needs no power to prime it; once a suitable lattice of fuel and moderator is assembled, heat appears. In a fusion system, however, electrical energy is required to heat the gas initially and to produce external magnetic fields. It is no use making a system which consumes 1 megawatt of electricity and only produces a further megawatt of heat, since some three megawatts of heat are required in the first place to produce one megawatt of electricity. Conditions for a favourable power balance are very stringent indeed, especially if the deuterium cycle is used.

The problems to be solved in achieving fusion power are formidable and it is by no means clear which road, if any, will lead to success. The whole subject is an exciting challenge, demanding the utmost in scientific imagination and technical ingenuity.

Thermonuclear Energy

In order to get useful energy from "heavy hydrogen", Sir George Thomson explained, one must be able to heat it to at least a hundred million degrees centigrade, which is hotter than the centre of the Sun. This happens instantaneously in an H-bomb, but for useful purposes the effect must be controlled and made to last something approaching a second. How is one to prevent the heat escaping prematurely, or indeed faster than it can be fed in so that the hydrogen never gets really hot at all?

There are three recognised ways by which heat can be lost: radiation, conduction, convection. Conduction to the walls of the containing vessel would be quite prohibitive. The problem is to prevent it, or at least greatly reduce it. Apparently the only practical method is by magnetic fields which may either be generated inside the gas by enormous currents or supplied from outside. In theory such a containment is possible and several methods have been suggested. Convection means the transfer of heat by the movement of masses of gas or liquid, for example, the shimmering effect seen on a hot day when one says the heat is rising. It is a kind of turbulence. For a thermonuclear device to work, this turbulent convection must be stopped, and it is not easy to do so.

Cancer and Cell Movement

Dr M. Abercrombie described how individual cancer cells infiltrate surrounding tissues by an active amoeba-like form of locomotion. Cancer cells are, however, far from unique in possessing the power of amoeboid locomotion. The great majority of animal cells have it. Such locomotion is a prominent feature in the development of new structure in animals; it occurs not only in embryonic development but also in the constructional processes of an adult, such as wound-healing. Most of the cells of an adult are, however, probably substantially stationary, unless they have been aroused to movement by some sort of repair process.

How does the control of the pattern of cell movement in one of these adult processes of repair, such as a healing wound, differ from that in a cancer similarly situated? In a wound, cell movement of the surrounding uninjured cells is, so to speak, switched on by the damage, takes place in such a direction as to fill the gap rather than to invade the uninjured tissues, and is switched off when the gap is filled. In the cancer, on the other hand, the movement is continuous and it does not respect the normal tissues.

The control of movement seen in a wound can in theory be accounted for by the operation of a single principle of interaction between cells. This principle contact is called inhibition; it has so far been studied only in the simplified conditions of tissue cultures of connective tissue cells. It works as follows: if one cell, while moving in a particular direction, makes contact with another, its movement in that direction is inhibited; a radical reorientation of its movement into some contact-free direction is likely to follow. A wound makes a space into which surrounding cells are free to move without making contact with other cells in their path. Such a space tends, therefore, to be filled, and when filled the mutual contacts stop the movement and the usual stationary state of the adult tissue is resumed.

A natural prediction of the theory of contact inhibition is that cancer cells should not be stopped in their movement by contact with normal cells, and that it is this failure of contact inhibition that produces their invasiveness. Sarcoma cells are malignant fibroblasts, and Miss Heaysman, Miss Karthauser, and Dr Abercrombie tested four different sarcomata for their contact inhibition by normal fibroblasts in tissue culture. All of them, even those hardly distinguishable in appearance from normal fibroblasts, proved to be not at all inhibited in their movements by normal fibroblasts.

It is suggested, therefore, that when a cell becomes malignant, one of the key changes is in its surface. As a result it no longer reacts to contact with other cells by checking or re-directing its movement. Its social behaviour is profoundly altered. It can now infiltrate amongst normal cells in a way which would otherwise be impossible, and this is the basis of its destructive properties.

Normal and Malignant Cells

By the use of physical and microscopic techniques Dr G. C. Easty and colleagues have demonstrated, using anti-tumour serum, that structural differences exist between transplanted tumour cells and various types of normal tissue cells of the host.

The first immunological method employed was the microscopic investigation using time-lapse cinematography of the action of an anti-serum prepared in rabbits against a transplanted mouse ascites tumour, on cells from the normal tissues and tumour cells of the mouse.

These workers' main interest was the investigation of any differences which

might exist between the surfaces of different cells. As most evidence suggests that rapid lysis (involving the death of the cell) by anti-sera results from its reaction with the cell surface, only short-term effects which might reflect these differences were observed in detail.

The original anti-serum lyses the tumour cells within seconds. Red blood cells and kidney cells lyse nearly as rapidly as tumour cells, and spleen cells more slowly. Liver cells remain apparently intact for several hours. Thus the liver cells have been distinguished from the kidney, spleen and red blood cells, and it has been shown that the tumour cell surface shares many antigens with the surfaces of normal cells.

The Electron Microscope and Cancer

The high resolving power of the electron microscope makes possible the study of structures which could not be resolved in light microscope and whose properties could only be inferred indirectly. Among these structures the external cell membrane is important, since it is that part of the cell which comes in contact with other cells and which, presumably, must enter into a semi-permanent relation with other cells in an established tissue.

Dr E. H. Mercer described how the development of an organised, differentiated structure can be followed electron microscopically in a few favourable instances. The aggregation of some unicellular organisms during part of their life history into multicellular formations and, in certain constantly growing mammalian tissues such as skin and hair. In such situations one finds that the cell membranes of the pre-differentiated cells are often highly convoluted. During the establishment of the tissue the free cell surfaces become sealed together by means of a very thin layer of intercellular cement forming two smooth parallel surfaces about 150–200 A. apart. The cement must play an important role. Sometimes the intercellular spacing is wider and sheets of material are interspersed.

What is Gravitation?

A paper by Mr J. L. Synge outlined some outstanding problems about the laws of gravity, including the gravitational waves recently discovered by Prof. Bondi and the two-body problem, which is an outstanding challenge in Einstein's theory, although simple enough in Newton's. He also referred to rigid motions, a concept which is easy in Newton's theory (the man-in-the-street knows that a rigid body is one which it is impossible to deform) but full of difficulty in Einstein's theory.

It took two hundred years, Mr Synge said, for mathematical physicists to gain a thorough mastery of Newtonian theory, and indeed they are working at it still. It will take a long time to gain a like mastery over Einstein's theory. We are still looking at the new theory too much in Newtonian terms, which leads to argument at cross purposes.

The Nervous System Like an Analogue Computer

W. K. Taylor reported that recordings of the electrical impulses generated by single nerve cells support the theory that information is communicated throughout the nervous system by means of impulse frequency modulation which is analogous to the F.M. used in radio transmission. Changes in amplitude of the modulating signal are represented by changes in the carrier frequency. In the nervous system the carrier frequency is very low, often being less than fifty impulses per second. He described how an assembly of electronic analogues of nerve cells was constructed and supplied with signals picked up by an electronic eye composed of photoelectric cells, each cell representing a cone of the retina. The assembly was used as an analogue computer for representing and testing theoretical models of areas of the brain. When set up to represent the visual association area, for example, the computer could be trained to recognise shapes such as squares, rectangles, and triangles, or up to half a dozen letters of the alphabet. The effects of changing the size of the assembly or the pattern of connexions could be investigated and the results compared with those of animal training experiments. There is every reason to believe that a larger assembly supplied by a larger eye would learn to recognise the entire alphabet and even words.

Chemicals in the Central Nervous System

It is well known that the nerves in direct control of muscles and other motor structures in the body transmit their messages by release from their endings of specific chemical agents that have been manufactured within the nerve cell and fibre. One of these substances, acetylcholine, is also to be found in the brain and spinal cord (*see* DISCOVERY, August 1956, p. 314). Dr Catherine O. Hebb has tried to find the specific enzymes which control the manufacture and destruction of acetylcholine, and from the results so obtained to deduce which neurones are potentially cholinergic (the name given to neurones which are known to release ACh from their ending). It has been possible to trace the origin and course of a number of neurones of this kind. For example, it appears that those which are second in the chain connecting the sense organs to the brain are always cholinergic.

In all mammals certain structures tend to have a high proportion of cholinergic neurones (for example, the caudate nucleus and the rhinencephalon) while others (such as the cerebellum) have a very low proportion. The only structure which shows a large evolutionary change is the neocortex. Here the proportion of neurones has become greatly reduced as the total numbers have multiplied. Non-cholinergic neurones must therefore make up the largest part of the cortical circuits in the human brain. It is possible that chemical transmission is incompatible with the other properties required for the operation of these circuits.

The Disjointed Octopus

In the hope of finding a suitable preparation for the study of learning processes, the brains of the cephalod molluscs—squids, cuttlefishes and octopuses—have been investigated and are proving to be peculiarly suitable material because there is a considerable structural separation of the parts concerned with sensory, integrative, and motor processes. Dr M. J. Wells studied the tactile system of the octopus to find out what the animal learns about objects by touch, and to discover the extent to which the parts concerned can be localised in the animal's nervous system. It appears that octopuses are unable to distinguish the shape of objects that they touch.

This seems to be a consequence of the extreme flexibility of the arms. Octopuses have no joints, so that the number of possible bending places and positions of its eight arms and two thousand-odd suckers is for all practical purposes infinite. It is most improbable that the animal has a sensory apparatus of the complexity necessary to define the relative position of its armtips, let alone of the suckers, at all accurately.

Adrenaline and Noradrenaline

In recent years the main pathway of the formation of the catechol amines in the mammalian body has been determined. Much use has been made in this work of radioactive tracer techniques, combined with chromatography.

Dr H. Blaschko described the pathway of the catechol amines as follows: phenylalanine→tyrosine→dopa→dopamine→noradrenaline→adrenaline.

This pathway seems to operate not only in the chromatin tissue, for example, in the medulla of the suprarenal gland, but also in the adrenergic neurones of the sympathetic nervous system, where the reactions leading to noradrenaline have been demonstrated.

Biogenesis of Natural Products

Radioactive carbon is chemically indistinguishable from normal carbon but differs in that it emits detectable radiations which enable its course through a series of chemical reactions to be readily traced; radioactive elements are often known as "tracers". It is as if, said Prof. T. S. Wheeler, one watched a company of soldiers enter a dark arena and after unseen drill emerge in another formation. By comparing the initial and final formations one might guess at the evolutions carried out in the arena. But if each tenth soldier (tracer-man) was "labelled" by a small lantern one could, by watching the interplay of lights,

arrive at a more accurate estimation of the drill in the arena.

Prof. Wheeler reported that the recent application of the tracer method to the synthesis of flavonoids has thrown much light on the biogenetic phenomena involved. Plants which produce a flavonoid called quercetin were fed with labelled compounds, that is, compounds containing radioactive carbon. The compounds chosen were those believed to be the precursors of flavonoids in the plant. By noting which labelled compound gave the greatest amount of radioactivity in the quercetin formed, it was possible to obtain accurate information on the course of the biosynthesis. Other methods which have been employed involve the use of mutant strains of algae to determine which of a number of test substances are metabolised into quercetin.

Light-Giving Insects

It is a known fact that insects are attracted to light. This fascination for light often leads to their own destruction.

There are a great many insects, especially beetles, with light-producing organs. Such insects are commonly known as glow-worms or fireflies. Prof. J. B. Gatenby and Mrs Gouri described the spectacular sight in tropical countries, during the rainy season, of a tree on which myriads of these fireflies assemble just after dusk; their rhythmical flashing of light forms an impression of tiny twinkling stars covering the whole tree.

The British glow-worm, *Lampyris Noctiluca*, is a beetle. The female is wingless and more strongly luminous than the male. The female form has two larger light-plates on the fifth and sixth abdominal segments, and four smaller plates on the fourth and seventh abdominal segments on the under surface. Light shines through the transparent skin of these segments from below and is visible even when the glow-worm always keeps its tail end a bit lifted up.

The light-organ in fireflies is a modified fatty tissue. Air, water and some photogenic substances are necessary for the light production. Glow-worm light is greenish yellow and is cold light, the most efficient light known, so far as amount of light for expenditure of energy is concerned. The glow-worm uses its light as a signal to bring its mate near.

A Solar Magnetograph

A new instrument for the detection of solar magnetic fields, the magnetograph, was described by Drs D. W. Beggs and H. von Klüber. Although it is not yet fully completed, the basic unit was successfully tested some months ago at the Observatories, University of Cambridge. Its sensitivity is such that it is capable of registering fields as low as one gauss over narrow strips of the Sun's surface about 100 seconds of arc long. There is in operation at the Mount Wilson Observatory, California, a similar magnetograph, the first instrument of this type, but the one at Cambridge is probably unique in Europe.

The method used in the magnetograph consists of placing two narrow slits on each wing of a line, $\lambda 5250{\cdot}2$, sensitive to to the Zeeman effect. The light from the slits fall on two photomultipliers connected to a difference amplifier. The resulting signal is amplified by a selective-frequency amplifier, followed by a phase-sensitive detector and a recorder. The analyser of the circular polarisation on the wings of the Fraunhofer line is a crystal of ammonium dihydrogen phosphate in conjunction with a polaroid. The crystal is excited by means of a potential of 3400 volts at 400 cycles/second. This type of analyser eliminates the systematic errors formerly obtained by the use of rotating quarter-wave plates.

How Rain is Formed

Dr B. J. Mason of Imperial College, London, described some recent researches in his laboratory which had thrown new light on the physical processes involved in the formation of clouds and rain.

The nature and origin of the tiny ice nuclei, which are necessary to initiate freezing at higher temperatures, are still something of a mystery. Dr Mason believes that they consist of rather rare and special dust particles carried up from the ground and did not support the more romantic theory that they originate as meteoritic dust entering the top of the atmosphere. Indeed, he has established that certain types of dust particles, belonging mainly to the clay minerals, act as highly efficient ice nuclei, while finely powdered meteor dust appeared to be inactive. The efficiency of certain of the nuclei originating as particles of soil or mineral dusts improved after "training", as Mason put it. Having once become involved in ice crystal formation, they become more effective at the second attempt. Thus ice crystals formed at high levels in the atmosphere might evaporate to leave behind nuclei which might fall down and "seed" underlying clouds at considerably higher temperatures than could "untrained" particles coming up directly from the ground.

Cloud-Seeding Experiments

Experiments on the artificial stimulation of rainfall were described by Mr W. Macklin. Individual clouds were seeded and their development closely observed. Information concerning the optimum conditions for rainmaking and the most suitable substance to use (in the economic as well as the physical sense) was thus gained. The second type of experiment sought to ascertain the effect, in terms of increased rainfall, of a prolonged seeding operation over a given area.

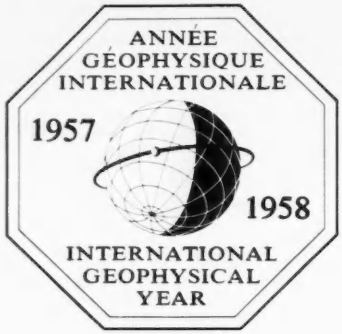
A thorough investigation of the effects of seeding individual clouds was carried out by Warner and Twomey. Nuclei were generated by injecting an acetone solution of silver iodide into the engine exhaust of the aircraft. Silver iodide, however, is very active chemically and attacked the exhaust pipe, and so special burners were developed. These consisted of a long flame tube in which the silver iodide solution was injected as a fine spray and then ignited by a spark from an engine-type spark-plug. The silver iodide was fed under pressure from the main cabin of the aircraft and consumed one to two gallons of solution per hour of operation, each gallon containing 500 grams of silver iodide. At the aircraft speeds used, about 4 grams of silver iodide would be distributed per mile, which is roughly equivalent to 10^{14} to 10^{15} effective nuclei per mile. Whenever possible the seedings were made at a level usually near the cloud-tops, at the temperature where silver iodide was considered to be immediately active as an ice nuclei. On the other occasions the silver iodide was released just below cloud base and the updraughts within the cloud were relied upon to carry the particles to the appropriate level. Observations were made both at the seeding level inside the cloud and from the cloud base.

Sex of Flowers

It has long been supposed that the sexuality of flowers is governed by hormones, and names have even been given to those supposed to be responsible for controlling the growth of the stamens and ovary, the sex organs of the plant. Such specific sex hormones have never been found in plant tissues, however, and one of the most interesting developments in recent years in our understanding of organ formation in flowers has been the discovery that auxins, hormones of the plant which are responsible for the regulation of stem and root growth, may also participate in determining sex.

Prof. J. Heslop Harrison said the method of regulation appeared to be rather a simple one, for in their reactions to auxins the organs of the two sexes have different growth optima, the male parts requiring lower concentrations than the female. Thus auxin levels favouring stamen growth are inadequate for ovary growth, whilst those favouring ovary growth suppress the stamens.

These results give a clue as to how various environmental factors may work in influencing the sexuality of plants. It has been known to gardeners for centuries that if marrows, squashes, etc., are planted too late in the year, so that their seedlings develop in the summer instead of in the spring, female flowers fail to form, and fruits may not be set at all until it is too late for them to ripen. This is because female flowers are produced most quickly when the days are short and the nights cool. It seems probable that these responses arise from the effects of day length and temperature on the formation and destruction of the natural plant growth substances.



THE INTERNATIONAL GEOPHYSICAL YEAR

MONTH BY MONTH

Compiled by Angela Croome

Conferences

The International Union of Geodesy and Geophysics (IUGG), which comprises seven constituent international associations in the geophysical sciences, held its triennial meeting in Toronto last month. The conference dates were September 3–14. As this issue went to press before the meeting was over, we are not able to carry an account of the proceedings this month.

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In October a meeting is planned in Washington of IGY scientists engaged on the satellite and rocket programmes. It is hoped that the Russians may there release the details still required to enable other countries to organise an effective satellite-monitoring network in readiness for the first Soviet satellite launching. Satellite size and brightness, intended orbital height, and the exact angle to the meridian at which it will be fired, are the most important tracking details that remain to be announced.

Also this month the annual meeting of the International Astronautical Congress is being held in Barcelona.

American Satellite Shrinks

The Americans have altered their plans for the first satellite to be launched in the series of twelve scheduled for the IGY. The new plan is for the first satellite to be 4·5 lb. in total weight and only 6·4 inches across—instead of rather bigger than a man's head with a total weight of 20½ lb. (most of which could be used for instruments). The new miniature satellite will only have enough apparatus on board to radio its position to the ground, but it can probably be launched as early as this November.

T.A.E. Moves

Before long the British Trans-Antarctic Expedition under Dr Fuchs will be moving out from its position on the Weddell Sea for the Pole and its rendezvous beyond with Sir Edmund Hillary and the New Zealanders. A second range of mountains has been found barring their way southward. Reconnaissance has shown a likely route through the nearer Theron Mountains; the Faraway Mountains (as they have been unofficially named) seem a tougher proposition. No reconnaissance beyond these of the terrain in the interior was possible last season. Meantime Sir Edmund has been asked, and has undertaken, to come 400 miles nearer than was originally planned to meet Fuchs's party on the Ross-Sea side of the Pole next year.

Soviet's Most Northern Observatory

The most northern Soviet observatory is nearly ready. It is being completed by a team of seventy-five builders in the remote archipelago of Franz Josef Land, beyond the Arctic Circle. A scientific team has been there since August. A group of the sounding rockets scheduled for the Soviet Union's IGY programme are to be fired in this area, and no doubt the new observatory will have some task connected with the passage of the Russian artificial satellite, whose orbit will reach that far north.

New World Low-Temperature Record

A new low-temperature record was registered in the Antarctic in April. The southern continent has now fulfilled meteorologists' expectations that it would prove to have considerably lower winter temperatures than anything in Siberia or northern Canada. The Americans at the South-Pole station recorded a reading of −100·4°F; at about the same time the Russian party at the intermediate station, Vostock I, 400 miles into the interior from Mirny, got a reading of −94°F, which also beats the globe's previous coldest meteorological temperature—in the minus 80's—recorded in Siberia. (See DISCOVERY, June 1957, p. 260, and January 1957, p. 32.)

Both these "lows" were recorded in April, and other data support the hypothesis that the overall Antarctic temperature for April this year was colder than for May.

New Cosmic-Ray Particle Identified?

Armenian cosmic-ray physicists claim to have discovered new particles of very high energy. They are prepared to exchange data with interested scientists and have already done so with physicists in Britain and the United States.

Reindeer and Glaciers

Reindeer are helping out with the supply problems of the mountain glaciological station recently set up on the Sutar Hayat ridge of Yakutia. East-German glaciologists are expected to revive German scientific interest in the glaciers of the Pamir region of central Asia, on the borders of Kashmir, Afghanistan, and China. German scientists worked in Pamir during the second Polar Year.

Ballooning News

The glamour of the Americans' rocket and satellite research has tended to overshadow their other upper-atmosphere studies. Nevertheless, important results have come from the series of large balloon flights which have been conducted by the U.S. Navy (which attends to the costly items of transport, launching, tracking, and recovery of material) in conjunction with various university groups who design the experiments.

These balloon launchings have taken place for the most part either from Texas, latitude about 41° N, or on the Equator.

Last January an equatorial programme of *Skyhook* flights was carried out, from a launching-site on an airfield on the Pacific island of Guam; helium-filled polythene balloons of 180 feet diameter when fully expanded were used. These are capable of raising an 800-lb. payload to 100,000 feet (about 20 miles high); the last one in this particular series of eight flights took this full load.

Results derived from the cosmic-ray experiments staged by the State University of Iowa team on this occasion are of some interest and relevance to IGY. They were first reported by Dr W. Webber at this summer's cosmic-ray conference of IUPAP at Varenna, in Italy.

More than 500 lb. of electronic equipment and photographic emulsions were suspended for 3½ hours at a height slightly above twenty miles, where the air density is only 0·1% of that at sea-level. The experiments were directed to observing the composition and intensity of the primary cosmic rays as they enter the atmosphere from space.

During these same Guam flights, tests were given to a proton precession magnetometer that has been developed by the State University of Iowa physics department under Dr Van Allen. During the IGY, fifty firings using similar apparatus carried by rockoons will be made in the Arctic, Antarctic, and equatorial waters in attempts to learn more about the Earth's magnetic field at altitudes of about 100 kilometres as well as to investigate the electric currents that flow in the upper atmosphere in the equatorial and auroral zones. This rocket-borne apparatus weighs only 6 lb., so may well find its way into later versions of the U.S. earth satellite also.

In August 1957 a team from Iowa headed by Dr Van Allen personally

launched the first of the upper-atmosphere IGY experiments of this type from the U.S. Navy's self-propelled floating dry-dock, the U.S.S. *Plymouth Rock*, operating at about 55° N. off Labrador. They used eighteen of the recently developed *Hawk* rockoons—small, relatively cheap, expendable rockets that rise as far as seventy miles high after being lifted the first ten to fifteen miles by balloon.

In September, Dr Van Allen transferred his attention to the Equator—and his operating-base to the U.S.S. *Glacier*, the big American ice-breaker, on the first stage of its journey to the Antarctic. Off the Line Islands, south of Hawaii, where the geographic and the geomagnetic equators intersect, more launchings will take place, and later this year there will be still more off the Antarctic continent.

In August, also, another Iowan cosmic-ray experiment was flown from *Skyhook* balloons from the joint Canadian-U.S. rocket base on the edge of the Arctic, Fort Churchill.

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During the latter part of this summer, Bristol University ballooning team from the cosmic-ray group of the physics department conducted seven large balloon flights from the Po Valley, in northern Italy. Some of the experiments flown were designed by the parent university, but a number of others came from continental groups, including some in Yugoslavia. An elaborate radio-tracking network was in operation, as the equipment is recoverable and the balloons were expected to float in a westerly direction and eventually reach France. For the first time the new salmon-pink polythene was being used for the balloons; it was thought that this might spread the heat more evenly through the fabric than the standard colourless type, and this might make the balloons less fragile when fully expanded in the unshielded glare of the sun at the top of the atmosphere.

It is hoped later to include a more detailed account of the Bristol ballooning.

*

American meteorologists in Antarctica have found a trick for getting their met-balloons (which are filled with helium) to fly higher than they otherwise do in the extremely cold atmosphere. The balloons are soaked in warm diesel fuel before inflation, and in this way the average height flown has been pushed up from 15,000 m. (April) to 21,000 m. in May.

Non-Magnetic Ship Visits Britain

The Russians have recently made two interesting additions to their already extensive oceanographic fleet; twelve of these ships are taking part in the IGY programme. The two ships recently enrolled in the programme are unique in different ways. They are the *Mikhail Lomonosov*, which will carry a mixed team of German and Russian oceanographers, and the *Zarya*.

The *Lomonosov* has recently been fitted with anchor cables 9½ miles long enabling her to anchor for considerable periods almost anywhere in the ocean. Another oceanographic ship, the *Vityaz*, which has an 8-mile long cable, recently returned from a cruise during which she dropped anchor in the Pacific—to an ocean floor nearly 6 miles below. This operation took 6 hours 50 minutes. It also broke the record established 35 years ago by a German ship for the deepest anchorage; this was only half as deep as the *Vityaz*' recent achievement.

The *Zarya*, of 580 tons, which was moored off Gravesend for some days earlier this autumn, is unusual in a different way. She is built entirely of non-magnetic materials and is in fact the only non-magnetic ship now in existence. She is made mostly of wood but with a 300 h.p. engine fashioned from bronze and gunmetal. She is schooner-rigged, and for the most part sails about her business; the small engine is strictly auxiliary.

The *Zarya* visited Britain on the first leg of a 50,000-mile voyage which during the next year will take her across the Atlantic to Halifax, Nova Scotia, round Cape Horn, and through the Pacific and Indian Oceans before she finally docks at Vladivostok sometime at the end of the next year. During her stay here she was checking her instruments with the Admiralty compass department and her magnetic equipment with the newly reorganised magnetic laboratory near Hartland. By checking with each of the navigation and magnetic centres in the countries she is visiting, the *Zarya* is able to carry with her the various world standards for immediate comparison. Her main contribution is expected to be in providing exceedingly accurate magnetic readings (both horizontal and vertical component) from mid-ocean, where few readings have previously been made. At the present time readings on magnetic charts at positions far from land are very approximate.

More Bomb Seismology

Though bombs have not been officially adopted as tools for IGY seismology, various large explosions, including bombs, are beginning to make an unofficial contribution to the programme. In the early summer a team of geophysicists were able to observe the seismic effects of the British H-bombs in the Pacific. Now this autumn the American Atomic Energy Commission has notified IGY seismologists round the world of the plan to explode an A-bomb *inside* a "small mountain" in Nevada. This method of detonation, though expensive, produces no fall-out. The mountain, though small, should be big enough not to fly apart after the explosion 800 feet underground.

Then, next year, the Canadians are to blow the top off Ripple Rock: a large obstruction to shipping in the Strait of Georgia off Vancouver Island. This operation is also to be monitored on seismographs for IGY purposes.

Taking the Pulse of the Arctic Ocean

Continuous recording of variations in sea-level at Point Barrow, off Alaska, over the past year seems to show that the tides in the Arctic Basin (which extends over the North Pole and whose rim is formed by North America on one side and Siberia on the other) fluctuate unaccountably back and forth between the supporting land masses. With the opening of the IGY the number of sea-level recording stations round the rim of the Arctic Basin has been greatly increased. With day-and-night readings going on at the one American station (Alaska), seven Canadian stations, and the four Soviet recording points from Wrangel Island to Murmansk, it should become clear whether the three- to four-day surges correspond with movements of large masses of water back and forth across the basin. By checking the arrival of surges on the Canadian shore with their appearance off Russia, oceanographers will be able to tell whether the three or four days' interval represents the time the same surge takes to travel from one side of the basin to the other. This may in turn give some clue to how they originate.

Altogether twelve sea-level recorders will be at work round the edge of the Arctic Ocean during the coming eighteen months.

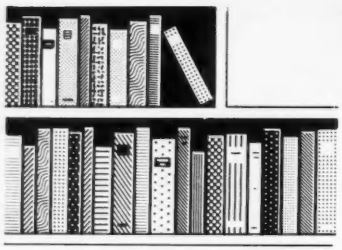
Explorers to Live in Plastic Sphere?

The plans and preliminaries for the joint central ice-cap expedition to Greenland, which is being organised by Expéditions Polaires Françaises and on which Danish, Swiss, and German scientists are collaborating, are now nearly complete. Paul-Emile Victor, the Director of Expéditions Polaires and Chef d'Expédition for the Greenland venture, has made two reconnaissances over Greenland this summer in connexion with the coming expedition. A meeting of the four-nation committee took place at Davos recently to tie up plans.

The idea is for a central ice-cap station to be put in next year and occupied by about fourteen men during part of 1958 and all 1959. The station will be situated on the crown of the Greenland ice-cap between 69° N and 72° N.

A new departure in polar building is being considered for the main expedition hut: a fibre-glass sphere instead of the conventional rectangular hut or the aluminium hut that the French use in Antarctica. In an area of high wind and heavy snowfall the round shape may have advantages. Once buried under the snow, as is expected to happen within months of arrival, the spherical, stressed shape should prove much stronger than other designs and will have no joints to give way. The heat-insulation qualities of fibre-glass should also be an advantage.

THE BOOKSHELF



Surveys of the Seas

By Mary Blewitt (*Macgibbon and Kee, London, 1957, 168 pp., 21s.*

This work is mainly concerned with surveys undertaken before the year 1865 and is confined to the activities of British surveyors and navigators; examples of the charts made by such well-known explorers as Cook, Vancouver, Flinders, and Bligh are given, as well as a score or more by less known surveyors, some of whom have honour only amongst the privileged few who are conversant with their contributions to the never-ending task of charting the seas of the world.

Miss Blewitt is to be congratulated on her choice of subjects for the monochrome plates, and for the two, and alas, only two, coloured ones: these cover the period 1670 to 1865, and there is in addition one modern survey of 1932 which would have rejoiced the heart of that eminent hydrographer, Sir Francis Beaufort, who on one occasion wrote to a dilatory captain: "All I require from you, my friend, is a harvest of soundings."

The laborious and, at the same time, rewarding search through the thousands of original documents in the archives of the hydrographic department of the Admiralty, which led to the selection of so representative a display of varied work, is deserving of much praise, while the succint captions facing each plate add to the interest. The portion dealing with the development of British surveying is both interesting and instructive; it shows clearly the steady advance in method and accuracy, the increasing reliability of the Admiralty charts and gives indication of the diligence and fortitude of those responsible for accumulating and putting into usable form the surveys of all descriptions which, from Dalrymple's time onwards, came in ever-increasing numbers from the surveyors afloat.

What is bound to strike anyone examining the plates is the apparent reluctance to make use of true bearings rather than magnetic, when describing leading and clearing marks; even as late as 1896, Vereker, some of whose beautiful views of the coasts of the British Isles are shown on page 156, gave all his bearings as magnetic. This practice has in the past given much trouble to cartographers when trying to reconcile differences of orientation. The view of Naxia, facing page 148, is sketched from a position on shore and would be of little use to the navigator, though possibly of interest to the archaeologist. There are many such in the view albums amongst the archives of the Hydrographic Office.

It is a great pity that it was not found possible to reproduce more of the plates in colour; many of them are extremely decorative, as will be gathered from the two plates at the beginning of the book.

The appendices are interesting, in particular Lt-Comdr Naish's brief summary of ships and instruments. J. A. EDGELL

Galileo Galilei, Dialogue on the Great World Systems

Translated by T. Salusbury, revised and annotated with an introduction by G. de Santillana (*Chicago University Press, 1953, lviii+506 pp., 3 plates, 32 figs., 9 diagrams, $12.50*)

This is the best edition of a most important classic in the history of science. Thanks to the triumphal scholarship of de Santillana, the translation made by Salusbury in 1661 has been rendered vibrantly glowing with all the excitement of that most crucial period in the history of science. The historical introduction is perfect, the explanation of the technical astronomy of the Copernican and Ptolemaic theory is magnificently carried out by W. D. Stahlman. The book is eminently readable, and more than any other single volume it opens a window into the past of science. This is fulsome praise. But it is the best book I know in my field. What more can a reviewer say? DEREK J. PRICE

Proceedings of the Symposium on "The Direction of Research Establishments" held at the National Physical Laboratory, September 26–28, 1956

(*Published by H.M.S.O., 1957, 25s.*)

Although at the beginning of this book it is stated that the Symposium was the first of its kind to be held in this country, some people—particularly those who have taken part in post-war research discussions arranged by the Federation of British Industries—will feel that "Research Direction" is a subject which has at least overlapped if not almost rivalled "Training" or "Scientific Manpower Shortages" as a topic for conferences, lectures, articles, and select editorials. Therefore it is a pleasant surprise that fairly familiar themes (such as attracting, recruiting, and accommodating staff; project selection, incentives, and research budgeting) have been dealt with in much of these Proceedings with an understanding and clarity which refresh and stimulate even those who are the chief targets of so much advice: the senior people trying to run research laboratories. Perhaps the key to this success is that those who wrote the papers, chaired the sessions, and contributed to the discussion have had really extensive and first-hand experience in the ranks and at the top of world-wide academic, government, and industrial research.

The vigour and realism of the approach is illustrated by phrases from an American paper and the respective Chairman's summary of a relevant discussion: "Engineers and Scientists are the most dissatisfied workers in industry. They are resentful of management, yet most of the resented managers are also engineers or scientists. The scientist, and indeed the human race, is particularly resistant to organisation which runs on what may be called military lines, and this is what makes both science and the human race interesting. The scientific method is an evolution of the human spirit in a different direction."

A special feature of this conference was the presentation and discussion of two papers describing progress in psychological research on research workers. The international nature of the conference is illustrated by the fact that these contributions referred to research at the University of Utrecht in the Netherlands, and the University of Chicago, U.S.A. Despite this geographical separation and the early stage at which such investigations stand, it is promising that both schools were largely in agreement that research attributes, such as "creativity", could be correlated with certain personality criteria evaluated from responses to professional psychological inquiry which, however, was distinct from the more conventional mental performance test. It does not seem unduly optimistic to expect that such research will eventually make real contributions on how to foster "creativity" and to career planning in industrial research, especially when ultimate transfer to other operations in the parent organisation is recognised as a logical move for some research recruits.

It was emphasised that administrative systems are necessary evils for organising the bulk of the workers in a research centre, and there are inevitably a few for whom special dispensations are essential and worth while. Although many people pointed out how difficult this is in any large laboratory outside a university, and hankered after a small organisation, it was agreed that for many projects a large unit is essential in giving the necessary choice of specialists covering the range of learning and skill required for an effective attack on the relevant problems. In a large unit, it is tempting to set up a range of centralised services. Some of these work very well —for instance, central workshops usually do—but this approach can be

overdone. For example, accepting that scientists can't write and managements can't read, it was advocated that the writing of papers and reports should be delegated to a centralised service of professional writers. This was rather hotly opposed by the majority, but one pharmaceutical research centre arranges such a scheme as part of the duties of a large technical information section numbering nearly sixty out of a total staff of 400.

With respect to buildings for research, the space allocation recommended is generous in allowing well over 200 sq. ft. to most types of worker, but some people would wonder why those in electronic development laboratories require less space than chemists. The subject of safety precautions was not very adequately dealt with. Emergency and alternative escape routes from laboratories, in case of accident, are important, as are such things as shower facilities for washing-off harmful materials after a mishap.

Teamwork in science, although probably originated in Britain, was felt now to be less in evidence here than in the United States. To be an effective team-worker, a man must have fairly broad interests in sciences other than his own speciality. In other words, he must be something of a team in himself. In stressing the potentialities of self-sufficient teams, it was nevertheless acknowledged that sponsoring work in appropriate outside organisations should not be an activity only of the laboratory possessing small research facilities. As a research laboratory grows, it may well be possible to formulate more and more projects for posing to other research organisations prepared to undertake them. This development has been well illustrated in the case of the growth of the Atomic Energy Research Establishment at Harwell.

The National Research Council of Canada now recruit about 60% of their young science graduates without an interview. They consider interviews too subjective to be of much value and, in dispensing with them, there is a tendency to study in greater detail all that is ascertainable about a candidate through means other than interviews. Often a more reliable assessment of academic ability can be achieved in this way, but it must be remembered that such a research organisation is not considering any of its recruits as possibly suitable for passing on at a later date to operations other than research.

Some delegates thought that long and elaborate induction courses for research recruits may be a waste of time, and recommended short courses specially tailored to fit the ultimate job in mind. Here again there will be a different outlook depending on whether the recruit is entering a Government research establishment or an industrial unit which may draw on its research centres for staffing any or all of its other activities. A session chairman recalled that, in assessing the work of a research laboratory, the most important product is the young scientist himself.

To show the delegates' unshaken confidence in the value of conferences of this and other types, there seemed to be general agreement that young research workers should be encouraged to attend at least one professional meeting a year, with group leaders spending considerably more time in such activities.

C. B. DAWES

Handbook of Tropical Aquarium Fishes

By H. R. Axelrod and L. P. Schultz (*U.S.A., McGraw-Hill Book Co. Inc., New York, London, 1956, xii+718 pp., 75s.*)

The two authors of this book should form an ideal combination for the production of such a work. Mr Axelrod is Editor of the "Tropical Fish Hobbyist Magazine" and a fish-keeper of repute himself, while Dr Schultz is Curator of Fishes in the Smithsonian Institution. They have tackled a difficult job—to write a book suitable for the aquarist who is not an ichthyologist and yet to be scientifically accurate. They have also tried to make the book as comprehensive as possible and decided to include every fish known to aquarium keepers in the U.S.A. and offered for sale during the past decade—449 species. It will be at once apparent that, unlike monographs dealing with the fauna of a region, or the classification of a particular family, this volume contains from a scientific point of view a rather odd collection of species, namely those of interest and available to hobbyists. These are, in general, the smaller colourful and peaceful freshwater fishes of the tropics.

A chapter on the elements of ichthyology is followed by another on the management of the aquarium. Both are adequate and authoritative, although it would have been pleasant to see more emphasis on function and less on anatomy in the first chapter. A third, short chapter deals with aquarium plants, and a fourth, by C. van Duijn, Jr, with the recognition and cure of diseases. Then follows a catalogue of fishes covering some 500 pages of profusely illustrated text, with 180 colour plates and several hundred other illustrations. Anyone familiar with the difficulties of obtaining natural-looking pictures of fishes will realise that it is no great criticism to state that a small percentage of these illustrations is poor, sometimes because ichthyological figures have been used, drawn originally to show details of such features as fins and scales, which do not always look much like the living fish. The great majority of the pictures of fishes are good to very good, with outstanding examples on pp. 182, 306, and 496 (*Carnegiella strigata, Puntius semifasciolatus* and *Mollienesia velifera*), all of which are colour photographs. There is no doubt that for the purposes of such a book as this, a really good colour photograph is by far the best illustration. The average aquarist identifies his fishes purely by recognition, and is not equipped to use the information in a scientific figure from which more certain identification might nevertheless be possible.

The arrangement of information is most satisfactory. Each fish (themselves arranged in families) is given one or more pages to itself headed by a picture. Its popular and systematic name with synonyms are followed by details of its range, size, temperament, heat requirements, sex differences, and fin counts in that order. Then follows a condensation of whatever is known about breeding the fish, raising the fry, and any other details of interest, with colour descriptions if the illustration is in black and white. This standard arrangement makes for very easy reference, aided by an excellent index. For general accuracy, and also for a welcome element of critical appraisal of various aspects of the subject-matter, this book is to be strongly recommended. There are undoubtedly a few errors, but none appears to be major. Altogether, this is a virtually indispensable compendium for the serious aquarist and must be accepted as the most comprehensive and authoritative volume of its kind available in the English language. It is a pity that in parts it seems too condensed, a feature apparently caused by an effort to keep down the retail price to a maximum of $10.00 in the U.S.A.

C. W. EMMENS

Electronic Computers

Edited by T. E. Ivall (*London, Iliffe and Sons Ltd, 1956, viii+167 pp., 25s.*)

An attempt has been made to provide an elementary introduction to the general principles and applications of modern electronic computers which will be suitable both for technical readers and also for those whose primary interest lies in commercial applications. The greater part of the material has been derived from articles written by some half-dozen authors and published previously in *Wireless World*, these being supplemented by chapters by the editor. An unusual feature of the book is that analogue and digital computers are given roughly equal weight.

After two introductory chapters covering the history of computers and the general principles of computing, most of the rest of the book falls into two main sections, the first covering analogue computers, and the second, digital computers. In each section there are chapters dealing with the type of circuits employed, the physical structure of the computers, and a general survey of applications. The section on digital computers has a chapter on the main types of storage systems which have been used. Somewhat surprising is the decision to restrict the discussion of the applications of digital computers as applied to scientific and engineering research work to one rather untypical example, on the grounds that most

applications of this nature are too highly specialised for inclusion. It is precisely in this field that digital computers have so far had their main successes. Most of the chapter on applications is devoted to a discussion of commercial problems, production planning, machine tool control, and automatic translation of languages; all of which are fields in which the full impact of electronic computers has yet to be made.

It is inevitable that a book of this type should suffer from a certain unevenness of style arising partly from the diversity of authors and the decision to cover such a wide field. Some chapters, particularly that on analogue computer circuits, demand some detailed knowledge of electronics for a full appreciation, while those on the applications could be followed by any intelligent sixth-former. The book provides a useful survey at moderate cost for those who wish to obtain a general idea of what is going on in this rapidly expanding field. J. H. WILKINSON

Parthenogenesis and Mammalian Development

By Alan Beatty (*Cambridge Monographs in Experimental Biology, No. 7, Cambridge University Press, 131 pp., 15s.*)

One of the agreeable things about a field of work which has only recently been opened up is that more or less everything known of the subject can be summarised within the confines of a single book. This is what Dr Alan Beatty's book has achieved for the subject in which he himself is a noteworthy pioneer. By its nature it cannot make light reading. But his lucid and logical catalogue of the two dozen or more routes by which mammals can come into existence, other than by the orderly division of a normal egg fertilised by a normal sperm, will be an indispensable *vade mecum* for the specialist. D. MICHIE

Statistics—A New Approach

By W. Allen Wallis and Harry V. Roberts (*Methuen, 1957, xxxviii+646 pp., 50s.*)

This book applies to statistics the same kind of approach that Prof. Lancelot Hogben used in his celebrated "Mathematics for the Million". Technicalities are avoided as much as possible and all the standard methods are clearly presented with the help of a large number of "do it yourself" examples. The book is obviously the fruit of long years of experience in teaching students of widely varying standards. The authors can claim with justification that "what is presented is coherent, sound, and useful, not faddish, tentative, or untried; in fact, we are confident that it will remain sound and useful half a century hence, whatever new developments may by then merit higher priority or suggest a different approach". J. L. NICHOLSON

Man and Automation

By L. Landon Goodman (*London, Penguin Books, 1957, 286 pp., 3s. 6d.*)

The difficulty about this book is that it reminds one of the nursery rhyme of the old woman who had "so many children she didn't know what to do". The trouble is that it has so many examples that one finds it very difficult to get a clear impression emerging at the end of its reading.

Perhaps the time has come when we should agree that quite enough books have been written on the general theme of automation, and that from now onwards we should concentrate on case problems or particular sections of the wide problem. After all, one of the long-term advantages claimed for automation is that its tools will enable us to accumulate abundant information, but to display that information on the exception principle, that is, to make available to managers and administrators only those significant portions which they consider essential knowledge for up-to-date understanding and control of the business.

The very plan and layout of the book are in some ways negations of this objective. The wide scope of the book certainly enables us to have between the covers a useful reminder of the many varied ways in which automation is today being applied, and the problems it is raising. It is, however, a

difficult book to read as it contains a mass of information in small print, and as such, relatively few managers would have either the time or the inclination to read it.

What section of the public do the publisher and author desire to reach? If it is the general public I suggest that they already have a number of very readable books giving a general background to automation. If it is the technical public, I believe, as I said, they are now due to have much more precise information on how to apply automation in particular sectors of the industrial and commercial field; in other words, they clearly want today more literature and examples which attempt to answer the question "How can automation help my company?" The general approach has now, therefore, to be brought into the particular.

Mr Goodman's experience and knowledge of this field is very great indeed, and his enthusiasm unbounded. He is technically competent to perform the more precise tasks that automation now demands, and one feels he would have done better to have harnessed his talents to, for instance, a book which did not attempt to cover every problem in the world, but to one which has relatively few main sections, in each of which a small but significant number of examples were developed much more fully than has been done before. WALTER PUCKEY

Through Alchemy to Chemistry

By John Read, F.R.S. (*London, G. Bell and Sons Ltd, 1957, xviii+206 pp., with numerous plates and line illustrations.*)

Prof. John Read's versatility is well-known. An eminent chemist, particularly in those branches of the science dealing with terpenes, essential oils, and simple asymmetric substances, he is also a successful dialect playwright, while his skill as a popular expositor of science was internationally recognised in 1949 when he was awarded the Cortina-European Prize for his "Direct Entry to Organic Chemistry". To many, however, he is best known by his delightful and scholarly books on alchemy and early chemistry, to which the present volume is a welcome addition. He provides the layman with an absorbing account of that "sliding science" which, over a couple of millennia, lured men of all ranks and occupations to spend their substance on attempts to transmute base metals into gold or silver and to prepare an elixir of immortality.

The story is complex, but Read is a master of his subject, and from the vast store of his knowledge he has distilled a quintessence of sparkling limpidity. The serious student of alchemy will realise how much learning lies behind every page of the book; the general reader will find a vivid picture of the tireless quest for the philosopher's stone and of those who pursued it. But, as the title of the book promises, Read proceeds to describe the lingering demise of alchemy and the beginnings of the modern science of chemistry. Here a lesser writer might well have failed, for early chemistry is not easy to follow; it is therefore pleasant to be able to say that the high standard of the first part of the book is fully maintained in the second. E. J. HOLMYARD

The Ancient Civilisations of Peru

By J. Alden Mason (*London, Penguin Books, 1957, 330 pp., 6s.*)

Man and Mammoth in Mexico

By Helmut de Terra (*London, Hutchinson, 191 pp., 25s.*)

The first of these books is as thorough as the other is superficial. J. Alden Mason has recorded every fact that is known about the ancient civilisations of Peru in a painstaking and systematic manner, so that the volume is a fitting companion to Vaillant's "Aztecs of Mexico" in the same series.

Helmut de Terra on the other hand has ranged over Mexico, sandwiching remarks about the modern cities between sidelong glances at Paricutín, various temples, the ice on 18,000-foot Ixtaccihuatl, and the Tepexpan fossil man. He seems unclear as to his purpose, whereas Alden Mason is quite sure of his. IRENE NICHOLSON

Digital Computers

By R. K. Livesley (*London, Cambridge University Press, 1957, 53 pp., 8s. 6d.*)

The modern engineer frequently needs to carry out extensive calculations, and for this purpose the slide-rule no longer gives sufficient accuracy. Fortunately to his aid has come the high-speed electronic computer. For many standard problems such as the solution of stress equations or the evaluation of modes of vibration of a system, answers can be readily obtained from existing computers. For work of a non-standard nature, the engineer himself may have to prepare the problem for the computer, an operation known as programming.

In his book which is based on a series of lectures given to the post-graduate apprentices of a large electrical firm, Mr Livesley gives an excellent introduction to computers, what they can do and how programmes can be developed. He begins with a description of the elements of programming using a simplified machine of the EDSAC (Cambridge University) type. Further refinements are gradually introduced, as for example the use of "subroutines" or standard pieces of programme. Another chapter deals with methods of storage of information inside a computer and also how to get numbers into and from the machine. Finally the author discusses the solution of engineering problems, giving examples from the standard repertoire of present-day computers. He concludes by stressing that the engineer should know something of the mathematical techniques useful in computer work in order that he may effectively use the new tools at his disposal.

The book is the second of the Cambridge Engineering Series designed to give post-graduate engineering students an introduction to allied subjects. This volume admirably satisfies its terms of reference and is to be recommended to anyone wishing to know what is involved in using a modern electronic computer. T. VICKERS

Brief Notes

The process developed by Australia's CSIRO's Division of Industrial Chemistry for saving water in dams is described in their Leaflet No. 15, which may be obtained free of charge from 314 Albert Street, East Melbourne, C.2. The process uses beads of an insoluble chemical called hexadecanol to restrict evaporation. Hexadecanol floats on the surface of the water and is prevented from being blown away by the use of a special raft anchored in the dam. A very thin invisible film spreads from the beads over the surface of the water. This film restricts evaporation. The beads supply additional hexadecanol to heal the film if it is broken. The process is recommended at present only for areas of water up to two acres, on which waves are small.

An increase of 50% in science laboratories of nearly 200 independent and direct grant schools which already have a sound scientific foundation on which to build will take place within the next two years, as a result of grants made by the Industrial Fund for the Advancement of Scientific Education in Schools. The report of this body has recently been issued and is the first full account of the work of the Fund to be published. Over £3 million have been subscribed by 141 industrial companies. The offices of the fund are at 20 Savile Row, London, W.1.

British Medical Bulletin, vol. 13, January 1957, is devoted to the Physiology and Pathology of the Kidney. In his introduction, Prof. Robert Platt says, "Three outstanding discoveries have influenced recent work on the kidney very considerably. I refer to the flame photometer which has facilitated so greatly the study of electrolyte metabolism; chromatography, which has made possible the study of specific failures in the tubular reabsorption of amino acids; and the discovery of aldosterone which now influences all our thinking on the relation of the kidney to sodium and potassium." Experts contribute sections on Renal Function in the Newborn, Tubular Secretion of Potassium, Volume Control of Body Fluids, Potassium Deficiency, the Kidney and Hypertension Urinary Calculus, and the Effects of Old Age and Over-Nutrition on the Kidney.

The National Research Council of Canada's Review for 1956, price 75 cents, is once again a testimony to the fine work being done in laboratories all over the country, in chemistry, physics, engineering, and biology.

SCIENCE ON THE SCREEN

Introducing Telex

Made for Creed and Company and the GPO by Introducing Telex/RHR Productions in Association with the Film Producers Guild. Producer, Ronald H. Riley. Black and white, 35 mm., 19¼ minutes.

This is a competent film describing what Telex is, how it works, and what are its advantages for firms who need to make large numbers of long-distance calls or foreign cables. Creed and Company of Croydon make all the teleprinters used in the GPO Telex Service, and the GPO supply the machines to subscribers on a rental basis, maintain them, and operate the associated Exchange and Directory facilities as for the conventional telephone system.

The film is primarily for showing to industrial and commercial organisations by the GPO, but 16-mm. prints will be available later on loan from Creed and Company.

I. NICHOLSON

Films on Rehabilitation

On the occasion of the Seventh World Congress of the International Society for the Welfare of Cripples a programme of about seventy films was staged. It could be called a "festival" since this is the second time that a "World Rehabilitation Film Award" has been made, the first being at The Hague in 1954. For this year's Congress forty-seven films from fourteen countries were entered for the award, along with another twenty-three which were sent in for screening only.

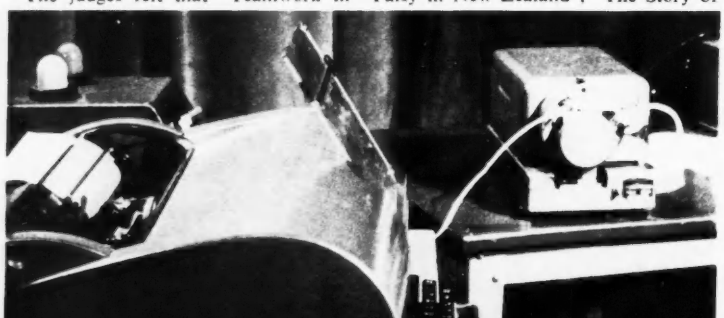
The judges felt that "Teamwork in Action", describing through a typical case history the function and philosophy of the Ontario Workmen's Compensation Board, best fulfilled the principles of the award. The following three films received certificates of commendation: "Still Going Places", "Ils Sont 200.000", and "Wonder of Work".

The impact of the film "Teamwork in Action", describing a highly organised scheme, is less on British minds conditioned by years of social medicine than on those from less highly developed countries. The application of such a scheme in other countries was no doubt in the judges' minds, though the benefits of such a scheme are arguable as its cost is directly reflected in the retail prices of the goods produced.

"Still Going Places" is probably the most interesting film for medical workers in Britain. Its refreshing new approach to geriatrics presents the experience of one New York Hospital in a convincing way. It commands attention throughout, though for most tastes it is a shade too long. The Indian Government film, "Wonder of Work", is primarily concerned with recruiting young people into the service of occupational therapy. It has an appeal and approach entirely Indian, and therein lies its success. The final film, "Ils Sont 200.000", made for and about the work of the Association des Paralysés de France, was the most enjoyable to watch, with its superb photography by Alain Pol.

Other films which drew public applause were the New Zealand Ministry of Health's "Treatment of Cerebral Palsy in New Zealand", "The Story of Dennis", "Miracle on Skis", and Dr Guttman's film of the World Paralympics, "The Stoke Mandeville Games".

FRANK BAMPING



A Telex Teleprinter (*left*) receiving automatically at top speed under the control of an automatic sender (*right*) fed with punched tape in which a message has been prerecorded.

Television

It is possibly asking too much to expect television broadcasts at this season of the year to include science programmes. Indeed, one has to scan both the BBC and the ITA programmes very closely to find even popular science. Apart from the perennial interest in underwater films, practically the only science item is the regular monthly BBC feature "The Sky at Night", to which fifteen minutes is devoted. During July, Patrick Moore talked about meteor showers. It was illustrated with excellent animated diagrams, and indeed so spoilt are we now that we seem to take it for granted that there *will* be good animated drawings. We ought not to forget the care and preparation which goes into the design of these diagrams and the technical excellence of their formulation. The lecturer was at times a little patronising. More than once he used the term "meteor radiant", forgetting to define this. It is difficult for an enthusiastic lecturer to avoid dropping, at times, into technical jargon, but to do so without an explanation is the cardinal sin in science broadcasting.

It was natural that the lecturer should exploit the fact that the Perseid meteor shower is due roughly in the first fortnight of August. With a series of good diagrams he showed how the constellation of Perseus can readily be identified. Then followed a clear exposition of the meaning of a "shooting star" and the origin of the showers, with stress placed upon the association between meteor showers and comets. We were then adroitly led on to consider the contributions which radio-astronomy is making to the subject. Perhaps it could have been more emphasised that radio methods enable showers to be observed during daylight. Possibly the title of the discourse justified neglect of this aspect. Stimulating, too, was the way in which the lecturer stressed possible relations between micro-meteors and the weather.

Photographs of the mighty craters of the Arizona and the Siberian meteorites were, of course, shown. Incidentally, I found it a pity that the lecturer did not emphasise the difference in meaning of the two terms "meteor" and "meteorite". As a boy I was sorely confused over this, being convinced that the term "meteorite" should refer to the smaller unit and not the larger. Perhaps, however, the modern tyro in astronomy is not so confused by the terminology.

The lecture ended on a slightly false note in that a picture of the Sun, complete with sun-spots, was flashed on the screen and we were informed that this was to be the subject for the discourse next month. But why the picture? It seemed quite out of place, following the excellent talk on the meteors and meteorites.

S. TOLANSKY

LETTER TO THE EDITOR

The Philosophy of Synthesis

Sir:

My main criticism of A. G. Cruft's article, "The Philosophy of Synthesis", (DISCOVERY, July 1957) is his blithe assumption that the laws of Nature are not opposed to the will of God as expressed in the phrase, "The function of Nature". I do not understand how, as an advocate of the Scientific Method, he can also support an omnipotent God. I would agree heartily with Cruft's excellent description of the Scientific Method as the direct appeal to Nature for truth instead of to authority, to be critical of all things, and to lay the onus upon the discoverer of truth to prove the claim rather than upon others to disprove it, to experiment under rigid control conditions, to provide a positive result in every case before a claim to have discovered knowledge and not to recognise finality. I would probably have added to the second phrase, "to be critical of all things", the words "especially one's own work"; but it is to the latter phrase that I would draw his attention: "the non-recognition of finality."

A belief in an omnipotent God is in effect the recognition of finality, and violates the Scientific Method. The expanding knowledge of our own universe from the infinite constituents of the atom to the infinite galaxies of outer space, surely suggests that there is no end to the improvement of man's knowledge. Why seek perfection in a God when there is no limit to truth and when it demands infinity in the expansion of our knowledge? It is to set an end-point to the infinite, to reach perfection when in effect you have said, there can be no perfection and there is no end-point in man's knowledge. It puts a chain on further thought, which is entirely unnecessary. From Lavoisier's Law, Einstein's Theory of Relativity, Darwin's Evolution, a study of Child Behaviour, an investigation of the age of the Earth and the development of solid matter from gases in the galaxies, an inquiry into societies and cultures in history, to a study of the possible origin of living matter in physics and biology, all Scientific Method cries out against the acceptance of a mythical and unnecessary God. What does emerge quite clearly is the infinity of forms, of matter, and of energy all in constant change. Here, then, is one scientific truth: man can advance his knowledge down the microscopic scale from the atom to its constituents and to the constituents of the constituents of the atom *ad infinitum*; also up the telescopic scale to galaxies into the outer space of our universe and beyond, again *ad infinitum*. Matter constantly changing has no beginning and no end, only the perceptible forms of matter have a beginning and end. The origin of, and end in, a God is quite unscientific. Why then does Cruft postulate that by the use of Scientific Method we are in fact exercising our limitless intellect which God has given us? To accept the idea of God is to accept an intellectual limit.

It is only on this single point that I disagree with Cruft. I believe sincerely in the humanistic approach he advocates and in the "religion" of Scientific Method. The divorce of many scientists and technologists from anything but their own sphere is to be deplored, but it appears inherent in the development of branches of science and the emphasis which colleges and universities put on the "question and acceptable answer" type of examination. Here the real problem is the wealth of knowledge which science embraces and which each branch of science has come to encompass. So that in any one subject we now have to learn many times the number of facts and laws that our predecessors had to learn. It is only understandable, therefore, that specialists are created and boundaries tend to be raised between one branch of science and another. This is the key problem, and how are we going to solve it? Perhaps the answer lies along a general science course of two years in our universities where the concentration would be on the links between the branches of science and the Scientific Method, succeeded by another two years in a particular branch. Greater reliance should be placed on scientific and technical libraries and less upon a parrot-like repetition of facts and theories to be found in most text-books. An extension of the time necessary for the completion of a degree is another suggestion, but one which will no doubt prove impossible with our present shortage of scientists and teachers. Cruft's article is very timely and welcome when he deals with these problems, and it is therefore most unfortunate that I cannot agree with him totally.

J. R. FARRANT

Sierra Leone
British West Africa

TWENTY-FIVE YEARS AGO

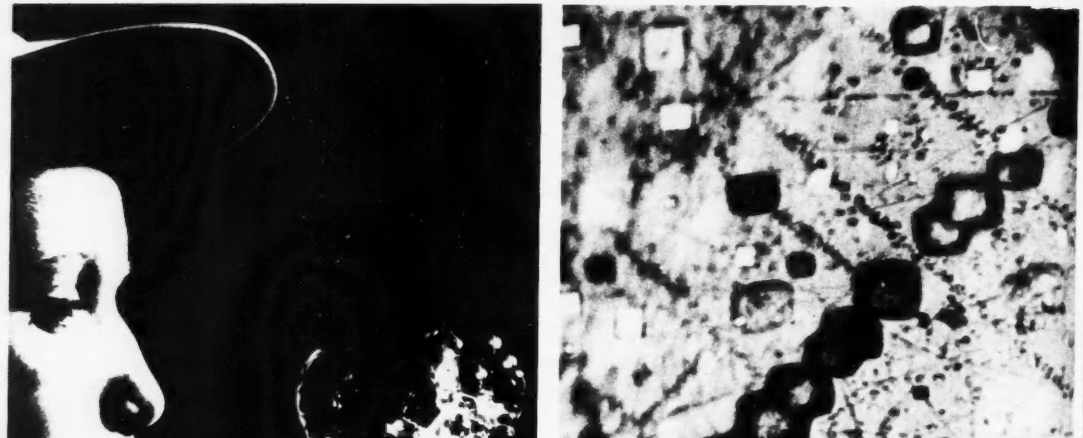
NEW FABRICS

An article in our issue for October 1932, "The Search for New Fabrics", by W. H. Gibson, Director of the Linen Industry Research Association, makes as yet no mention even of the possibility of plastic fabrics such as the modern harassed office worker and housewife relies on to make her laundering and ironing simpler.

"The production of fabrics", the article says, "is the age-old solution provided by civilisation for those primary problems of mankind, the provision of clothing, for warmth and adornment, and of shelter from the elements, of a temporary, movable or accessory nature." Such secondary problems as time-saving are scarcely considered. "Through the ages the world has been ransacked for raw materials suitable for conversion into fabrics, and with the development of the great classifying sciences, thousands of animal and vegetable fibres are known to be more or less available and suitable for fabric construction. Nevertheless, the position of silk, wool, linen and cotton, which have been used since time immemorial, seem more firmly established than ever." This is undoubtedly true today, since nothing can take the place of the natural pile and surface textures of these materials. Nevertheless, for certain uses, nylon, orlon, Terylene, and the rest, have come into such constant use that they are practically essentials of modern life.

"Recently", the article continues, "the development of chemical methods for the conversion of cheap vegetable fibres into lustrous filaments has resulted in the production of artificial silk or rayon fabrics. The triumphs of the biological sciences in the textile field are apparent in the brilliant application of genetics to animal and plant breeding."

The article ends with the following thoughts, which are still pertinent today: "Many men, and particularly women, now believe that the skin itself should be soothed and refreshed by contact with a fine, smooth, and absorbent fabric, and in this the influence of physiological thought is seen. Physiological science has thus changed the nature of the demand for textile fabrics very materially, and has provided an incentive for research which seeks to correlate what may be termed the hygienic properties of fabrics, as discovered by physiological researches, with their physical properties, their structure and their composition. Progress in this direction is slow and difficult owing to the differing types of human constitution and their differing reactions to their surroundings, but we may hope that ultimately the degree of influence of appropriate clothing upon bodily fitness may be scientifically determined."



Square bubbles.

FAR AND NEAR

Square Bubbles

Round soapy bubbles have for ages been made by boys for their own special enjoyment with clay pipes. Now metallurgists at the Knolls Atomic Power Laboratory Schenectady, have discovered square bubbles in nature.

Scientists have found microscopic bubbles in square and rectangular forms inside lithium fluoride crystals after they had been irradiated with neutrons in a reactor heated above 600°C.

The above photograph shows ordinary soap bubbles (*left*) and the square bubbles (*right*) found in lithium fluoride. They were only three one-hundred-thousandths of an inch thick, and are magnified about 400 times.

Fishery Training Centre

The Government of Australia has formally undertaken to conduct a six-weeks training course for personnel from sixteen countries of the Indo-Pacific region who are concerned with the development of fisheries co-operatives. Australian representatives have signed an agreement between their Government and the Food and Agriculture Organisation arranging for the course, which will be held between December 16 and January 25 next. The Government of Canada will also co-operate, providing a co-director from the Province of Saskatchewan's Department of Fisheries. The first month of the course will be held at Sydney University, and participants will thereafter do field work at various South Australian fishing ports.

The Indo-Pacific Fisheries Council, which met recently in Bandung, Indonesia, requested FAO to organise a training centre to help the member countries in their drive to increase fish production as an answer to the urgent need for more animal protein food. FAO officials said that co-operatives form an important part of the developmental plans of these governments. But the traditional credit structure and the fisherman's poverty and illiteracy had retarded the progress of the co-operative movement, and there was pressing need for a well-trained leadership which could establish co-operatives on a sound basis and make them work efficiently.

The FAO officials also said that there is an acute shortage of trained officers in government departments which are helping their fishing industries to develop the co-operative movement.

Nuclear Courses for Teachers

A hundred teachers in universities and higher technical colleges, from fourteen European countries, have attended courses in nuclear energy organised, at the instigation of the Organisation for European Economic Co-operation, and the European Productivity Agency, by the Atomic Energy Research Establishment at Harwell and the Centre d'Etudes Nucléaires at Saclay. These courses, which aim at assisting teachers in keeping up to date with the latest progress in nuclear techniques, are part of a programme to develop the teaching of nuclear subjects in universities and smaller institutions.

Foot-and-Mouth Disease Research

The Wellcome Trustees have made a grant of up to £80,000 to the Government of Kenya towards the cost of building and equipping a special establishment for research on foot-and-mouth disease. The Institute, which will be sited in the Nairobi area, will be under the control of the Kenya Veterinary Department. It will be known as "The Wellcome Institute for Research on Foot-and-Mouth Disease".

Air-Pollution Tests at Bolton

An enterprising piece of municipally sponsored research is reported from Bolton, Lancashire. The local Council have passed a resolution that research should be carried out on air-pollution, especially on invisible air pollutants likely to be of significance in the incidence of respiratory diseases. For this purpose it is proposed to establish air-sampling stations at nine selected sites in

the borough. These will be arranged on three parallel lines across the town in the form of a grid, with three stations on each line. The sampling apparatus will operate continuously, passing a metered volume of air through filter-paper and a reagent solution to enable oxides of sulphur to be determined. An oil company in the district has offered the free services of a statistician to help in analysing the results. The aim is particularly to assess the changes in the air-pollution caused by changes in domestic and industrial practice as a result of the provisions of the Clean Air Act, 1956. The work will be carried out by the public-health inspectors collaborating with the public analyst. No specific complaints have been made against chemical works or other similar normally suspected sources, but it is noteworthy that Bolton has the second highest rate for chronic bronchitis in the country.

Mawson's Plaque

Sir Douglas Mawson has strongly opposed a suggestion that a plaque discovered by the present Australian Antarctic Expedition 60 miles from the Mawson base should be brought back to Australia. Sir Douglas said that he had erected this and four other cairns containing messages in copper cylinders, asserting British sovereignty, during the 1930–1 expedition. It would be quite wrong, he declared, to remove the plaque. When an explorer took possession of an area, it was an official act for his Government. He would not mind if the present expedition, as suggested, built a larger cairn so long as his plaque remained where it was.

Smallest Gas Turbine Engine

Solar Aircraft Company of San Diego is designing and preparing to produce the smallest gas turbine aircraft engine ever built. Only 20 inches high, with maximum diameter of 15½ inches, and weighing only 50 lb., the tiny engine will produce 55 shaft horsepower plus 12 lb. of jet thrust, and it will be used to power a one-man helicopter. The company is to produce the new engine under a joint contract from the Navy Bureau of Aeronautics and the U.S. Army. Known as the Solar Mercury, the engine's military designation is the YT-62. The Mercury will operate on standard military fuels, and the engine's rotor will spin at 57,600 r.p.m.

Cloud-Seeding to Stop Forest Fires

Foresters and meteorologists in Montana and Idaho, United States, are joining forces to combat the ravages of forest fires caused by lightning. Experiments are being carried out in the two States this summer to seed thunder-clouds with silver iodide which will change the droplets into ice. In this way it is hoped to stop the clouds' upward growth, which occurs before lightning is produced. Preliminary tests held last year included the use of radar equipment to track lightning storms.

Statistics show that 100,000 forest fires caused by lightning were recorded between 1940 and 1955 in twelve States in the Rocky Mountains and Pacific Coast area. If information gathered this year shows the method is effective, the technique will be used in other areas.

Antarctic Mineral Resources

New Zealand scientists plan to make use of transport and bases organised in Antarctica for the International Geophysical Year to carry out a geological survey of the Ross Dependency and the northern part of South Victoria Land. Working from the joint New Zealand-United States base at Cape Hallett, the expedition will map the little-known territory of the Ross Dependency, and will seek to establish the geological connection between east and west Antarctica. Reports have been received of extensive coal deposits and traces of copper, iron, molybdenum, and gold.

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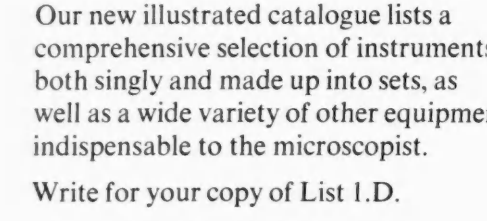

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Classified Advertisements

OFFICIAL APPOINTMENTS

MINISTRY OF LABOUR AND NATIONAL SERVICE. H.M. INSPECTORS OF FACTORIES (CLASS II). The Civil Service Commissioners invite applications from men and women for pensionable posts in the Factory Inspectorate, which is being expanded. Age at least 21 and normally under 30 on June 1st in the year of application. Extension of the upper age limit for regular service in H.M. Forces and for candidates with exceptional qualifications. Starting salary £545 (at age 21) up to £710 at 26 or over. Scale maximum £980. Somewhat lower outside London. A special increment of £25, within the scale, is granted after satisfactory probation Higher posts filled by promotion from Class II. The salaries are now subject to an increase of the order of 5 per cent.

Duties include the enforcement of the provisions of the Factories Acts and Regulations affecting the safety, health and welfare of work-people and extend to all manufacturing industries and to certain other places, including Docks, Works of Engineering Construction and Building Operations.

Candidates should normally have a university degree (which may be in science or in arts subjects) or have technical qualifications of comparable standard (e.g. A.M.I.Mech.E.). Experience in works or other practical spheres is an advantage.

Candidates without degrees or similar technical qualifications will be considered if they have had extensive works or other practical industrial experience (especially in responsible positions) and if they have good general or technical qualifications.

Application may be made at any time, and so long as there are vacancies suitable candidates will be interviewed.

Particulars from Secretary, Civil Service Commission, 6 Burlington Gardens, London, W.1, quoting No. 280.

EXPERIMENTAL OFFICERS AND ASSISTANT EXPERIMENTAL OFFICERS in various Government Departments. The Civil Service Commissioners invite applications for pensionable posts.

The posts are divided between following main groups and subjects: (*a*) Mathematical and Physical Sciences, (*b*) Chemistry and Metallurgy, (*c*) Biological Sciences, (*d*) Engineering subjects, and (*e*) Miscellaneous (including e.g. Geology, Library, and Technical Information Services).

Age Limits: For Experimental Officers, at least 26 and under 31 on December 31, 1957; for Assistant Experimental Officers at least 18 and under 28 on December 31, 1957. Extension for regular service in H.M. Forces. Candidates aged 31 or over with specialised experience for Experimental Officer posts may be admitted.

Candidates must have at least one of a number of specified qualifications. Examples are Higher School Certificate, General Certificate of Education, Scottish Leaving Certificate, Scottish Universities Preliminary Examination, Northern Ireland Senior Certificate (all in appropriate subjects and at appropriate levels), Higher National Certificate, University degree. Candidates taking their examinations in 1957 may be admitted provisionally. Candidates without such qualifications may be admitted exceptionally on evidence of suitable experience. In general a higher standard of qualification will be looked for in the older candidates than in the younger ones.

Salary (London):

Experimental Officer. Minimum £970 (women £894); Men's scale maximum £1190.

Assistant Experimental Officer. Starting pay £385 (at 18) up to £685 (women £661) at 26; Men's scale maximum £850. Women's scales are being raised to reach equality with men's by 1961. Somewhat lower outside London. Promotion prospects.

Opportunities for further education.

Further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S94-95/57.

Interview Boards arranged at intervals, as required. Early application is advised.

ASSISTANTS (SCIENTIFIC). The Civil Service Commissioners invite applications for pensionable posts.

Age at least 17½ and under 26 years of age on January 1, 1957, with extension for regular service in H.M. Forces, but candidates over 26 with specialised experience may be admitted.

Candidates must produce evidence of having reached a prescribed standard of education, particularly in a science or mathematical subject. At least two years' experience in the duties of the class gained by service in a Government Department or other civilian scientific establishment or in technical branches of the Forces essential in one of the following groups of scientific subjects:

(*i*) Engineering and physical sciences.
(*ii*) Chemistry, bio-chemistry, and metallurgy.
(*iii*) Biological Sciences.
(*iv*) General (including geology, meteorology, general work ranging over two or more groups (*i*) to (*iii*) and highly skilled work in laboratory crafts such as glass-blowing).

Starting pay £355 (at 18) up to £485 (women £454) at 25. Men's scale maximum £665. Women's scale being raised to reach equality with men's by 1961. Somewhat less in provinces. Opportunities for promotion and for further education. Five-day week, generally.

Further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S59/57.

Interview Boards sit at intervals, as required. Early application is advised.

SENIOR SCIENCE TECHNICIAN required by NIGERIAN COLLEGE OF ARTS, SCIENCE & TECHNOLOGY for two tours of 12–24 months in first instance, either (*a*) with prospect of pensionable employment with salary scale (including Inducement Addition) £774 rising to £1410 a year, or (*b*) on temporary terms with salary scale (including Inducement Addition) £834 rising to £1530 a year plus gratuity at rate £100/£150 a year. Commencing salary according to experience. Outfit allowance £30/£60, according to salary. Free passages for officer and wife. Assistance towards children's passages and grant up to £150 annually towards maintenance in U.K. Liberal leave on full salary. Candidates must be A.I.S.T. Duties comprise supervision of all College laboratories and stores. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience, and quote M3/44341/DI.

APPLICATIONS are invited for pensionable posts as

EXAMINERS
in the
PATENT OFFICE

to undertake the official scientific, technical, and legal work in connexion with Patent applications.

Age at least 21 and under 35 years on January 1, 1957, with extension for regular Forces' service.

Candidates must have (or obtain in 1957) 1st or 2nd Class Honours in Physics, Organic or Inorganic Chemistry, Mechanical or Electrical Engineering or in Mathematics, or an equivalent qualification, or have achieved a professional qualification, e.g. A.M.I.C.E., A.M.I.Mech.E., A.M.I.E.E., A.R.I.C. For a limited number of vacancies candidates with 1st or 2nd Class Honours degrees in other subjects—scientific or otherwise—will be considered. Exceptionally, candidates otherwise qualified by high professional attainments will be considered.

Starting pay for five-day week of 42 hours in London between £605 and £1120 (men), according to post-graduate (or equivalent) experience and National Service. Maximum of scale £1345. This salary scale is being increased by approximately 5%. Women's pay above £605 slightly lower but is being raised to reach equality with men's in 1961. Good prospects of promotion to Senior Examiner rising to £2000 (under review)

and reasonable expectation of further promotion to Principal Examiner.

Application form and further particulars from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S128/57 and stating date of birth.

Interview Boards will sit at intervals, as required. Early application is advised.

APPOINTMENTS VACANT

STANDARD TELEPHONES AND CABLES LIMITED

APPLICATIONS are invited for the Transistor Division:

1. *Senior Scientists.* Physicists and Electrical Engineers for work on fundamental concepts in solid state physics and S-C device design. Good Honours degree (a higher degree may be preferred) and some research and/or industrial experience essential.

2. *Mathematicians (male and female)* to work for above group and device development and application department. Honours degree essential.

3. *Physicists and Electrical Engineers.* B.Sc. or equivalent for device development department. These posts will also suit post-graduates without previous experience.

Attractive salaries are being offered and terms and conditions of service at this "garden" site, within easy reach of Charing Cross, are excellent.

Applicants should write, with brief with details, in confidence to:

W. J. Yeomans, Personnel Manager, Standard Telephones and Cables Ltd, Footscray, Sidcup, Kent.

SEMICONDUCTORS

THE
RESEARCH LABORATORIES
OF THE
GENERAL ELECTRIC
CO. LTD.,
NORTH WEMBLEY,
MIDDLESEX,

invite applications from GRADUATE PHYSICISTS and ENGINEERS to fill vacancies which exist in their research teams engaged on the development of Semiconductor Devices. This work is interesting and challenging and the posts offer prospects of promotion to positions of senior responsibility within the Company.

Apply in writing to the Staff Manager, (Ref. RLO/150), giving full particulars of qualifications, experience and age.

CRYSTAL ANALYSIS

THE RESEARCH LABORATORIES
OF THE
GENERAL ELECTRIC CO., LTD.,
North Wembley, Middlesex,

have a vacancy for a PHYSICIST or CHEMIST to assist with a programme of work in the field of CRYSTAL ANALYSIS, with particular emphasis on magnetic and ferro-electric materials. Experience in x-ray diffraction methods is desirable, but not essential.

This position offers considerable opportunity of advancement to a graduate who is interested in this field of work.

Candidates under 26 years of age must have completed or be exempt from National Service.

Apply in writing, to the Staff Manager (Ref. RLO/148), giving full particulars of experience, qualifications and age.

ELECTRONIC (OR CIRCUIT) ENGINEERS

APPLICATIONS are invited for the following positions.

1. *Transistor Applications Engineers.* A new Department of the Transistor Division requires Engineers, with either B.Sc. or H.N.C. qualifications, to work on a wide range of transistor applications exploiting an increasing range of semiconductor devices.

2. *Engineers and Assistant Engineers.* B.Sc./H.N.C./O.N.C., required for Transistor Measurements Group to work on investigations into measuring techniques of semiconductors, and to carry out a wide range of practical experiments. Senior positions also available in this group for Engineers with several years' laboratory experience.

3. *Engineers,* B.Sc./H.N.C./O.N.C., for the development of test gear and industrial control equipment.

Attractive salaries are being offered. Non-contributory Pension Scheme, and good terms and conditions of service. Anyone interested is invited to write, details, in confidence to:

W. J. Yeomans, Personnel Manager, Standard Telephones and Cables Ltd, Footscray, Sidcup, Kent.

REFRIGERATED CARGO RESEARCH COUNCIL, Falcon Yard, Cambridge, require the services of a RESEARCH OFFICER, for work in connexion with marine refrigeration and overseas transport of perishable foods. Applicants should have a high standard of academic or technical qualification preferably in physics or engineering and should preferably be less than thirty years of age. Experience in research or technical development will be an advantage. The post will carry a salary proportionate to the experience and qualification of the successful applicant and will qualify for admission to a superannuation scheme. Applications, which should include all relevant details of education and previous career, should be made by letter to the Secretary, Refrigerated Cargo Research Council, Cunard House, 88 Leadenhall Street, London, E.C.3.

BOOKS WANTED

DISCOVERY—Volume 4, No. 4, and Volume 5, No. 5. The Book Buyer, Room 126, H.M.S.O., Cornwall House, Stamford Street, London, S.E.1.

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